# GLIMPSES OF THE PUNJAB.





UNIVERSITY HALL, LAHORE.



## Indian Science Congress,

1927.

# GLIMPSES OF THE PUNJAB.

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## A SOUVENIR

of the 14th Meeting of the

# Indian Science Congress

HELD AT

Lahore in January, 1927.

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EDITED BY

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AND

THE REV. C. H. RICE, M.A. (WOOSTER),
PH. D. (PRINCETON).

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1927.

# TABLES OF CARRIAGE FARES,

## LAHORE.

### MOTOR CARS.

| | Annas. |
|---|---|
| For the first mile or part of a mile .. | 8 |
| For every subsequent quarter mile .. | 2 |
| For every minute of detention .. | 1 |

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| To Shahdara, Shalamar or Lahore Cantt. including return hire .. .. .. .. | 1 0 0 |
| *Plus* per hour or portion of an hour when detained | 0 5 0 |
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| BEYOND MUNICIPAL LIMITS. | |
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| *Plus* per hour or portion of an hour when detained | 0 5 0 |
| To Nawakot or Ichra including return hire .. | 0 10 0 |
| *Plus* per hour or portion of an hour when detained .. | 0 5 0 |

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| WITHIN MUNICIPAL LIMITS. | |
|---|---|
| For first hour .. .. .. | 1 4 0 |
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| BEYOND MUNICIPAL LIMITS. | |
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| *Plus* per hour or portion of an hour when detained .. | 0 12 0 |
| To Nawakot or Ichra including return hire .. | 1 12 0 |
| *Plus* per hour or portion of an hour when detained .. | 0 12 0 |

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Diwan Anand Kumar, M.A.

# INTRODUCTION.

In offering this Handbook to the Members of the Indian Science Congress, Lahore, 1927, the Reception Committee has much pleasure in welcoming them to a Province and City, whose varied interests and activities form a fitting background to their labours in the cause of science.

As a Province, the Panjab has some special features. In Lahul and Spiti (in Kangra District) it possesses practically pure Tibetan Valleys, with a Tibetan population. In the Salt Range area it exhibits geological features of rare interest, which are discussed in Chapter IX of this Handbook. In the great steppes and grazing grounds for camels and cattle in the Sind-Sagar Doab we have the conditions prevailing among the pastoral nomads of Central Asia. In the Thals, or deserts of shifting sand, near Multan, we are in touch with conditions like those prevailing in Sindh, Arabia, or the Sahara.

In contrast with these, we have a system of canal irrigation, bold in conception and wonderful in design and execution, which has converted millions of acres of barren land into fertile fields and orchards, and given the Panjab an important place as a wheat granary of the Empire (see Mr. Sangster's account in Chapter IV). So successful is our canal system that the Panjab earns two-thirds of the direct nett canal revenue on only a quarter of the capital outlay for the whole of British India. The town and colony of Lyallpur are fittingly described, in an inscription at the fountain in the centre of the bazar, as the gift of the river Chenab (*Barkat Chenab Nadi*). The wealth of modern Punjab agriculture may well be described as the gift of the Five Rivers, as is suggested by the motto and coat of arms of the Panjab Government.

But the water power of the Panjab and of the sacred Himalaya, from which it springs, is not only being utilised for the production of agricultural wealth. Science can also convert it into light and power for industrial production. The hydro-electric schemes of the Panjab are still in their early stages, but they promise within a generation to supply the Panjab with cheap water power distributed in bulk by a chain of stations linked together to form one electrical system, extending from Peshawar to Delhi. How this can be done is described by Colonel Battye, R. E., in Chapter V. The first stages of the project include a diversion of a snow-fed river through two miles and a half of a tunnel, 9 feet in diameter through solid granite at an altitude of 6,000 feet above the sea.

Industrial development presupposes a good railway system, and the Panjab fortunately possesses one in the North-Western Railway, which serves six provinces and has many remarkable features described by Captain Wagstaff (Chapter VI). The Workshops of this Railway at Lahore comprise the Signal Engineers'

Workshops ; the Locomotive Shops, which employ 5,300 men and can thoroughly overhaul 400 engines a year ; and the Carriage and Wagon Shops, which employ 5,800 men, and can build 500 four-wheeler units of coaching stock per year and repair 5,000 units of coaching stock, and 10,000 goods wagons. A visit to the headquarters Offices of the Railway in Empress Road will show what a big place the Railway fills in the economic life of the Province and what progressive ideas and businesslike methods guide its destinies.

But after all, the vast proportion of Panjab's 24 millions of sturdy inhabitants depend on agriculture, and scientific agriculture is one of the most pressing needs of the Province. This subject has specially been before the public eye recently on account of the advent of an agricultural Viceroy and the Royal Commission on Agriculture. Mr. Milne describes the chief features of Punjab agriculture (Chapter X), and his remarks on the splendidly equipped Agricultural College at Lyallpur will be of special interest to scientists. Allied to Agriculture is the question of Forest conservation and the development of forest resources, in the matter of grazing, fuel, timber, and raw material for industries, and the preservation of moisture and water in the soil, and these questions are discussed by Mr. Blascheck, the Chief Conservator of Forests, (Chapter VII). Veterinary Science, including the breeding of horses and cattle, and veterinary education, are as advanced in this Province as anywhere else in India and some facts about them are summarised by Mr. Taylor (Chapter VIII).

This brings us to the subject of education. Mr. Wilsdon shows us by means of a graphic diagram (Chapter III) the progress and popularity of science teaching in Lahore, and many of its well-equipped Laboratories will be on daily view before members of the Congress. Mr. Hemmy has described the Lahore Colleges generally (Chapter II) and drawn attention to the concentration of students in the capital city of the Province and the extensive provision of hostel accommodation. It is computed that, of the 10,890 students reading last year in the Colleges of the Panjab, the Frontier Province, and the Indian States within the territorial jurisdiction of the Panjab University, nearly 6,000, *i. e.*, considerably over a half, were studying in Lahore. In addition there were nearly 11,000 children reading in Lahore schools. The Medical College and the hospitals connected with it are described by Colonel Broome (Chapter XI). Other professional Colleges are the Law College and the projected College of Commerce. For higher engineeeing the Punjab has still to go to Rurki. It may be mentioned that the Panjab University has always had a teaching side ; that this side is being gradually developed further, especially in its Honours Schools and its science teaching ; and that this development has not passed without adverse criticism on the part of Mufassal Colleges, which find themselves placed at a great disadvantage

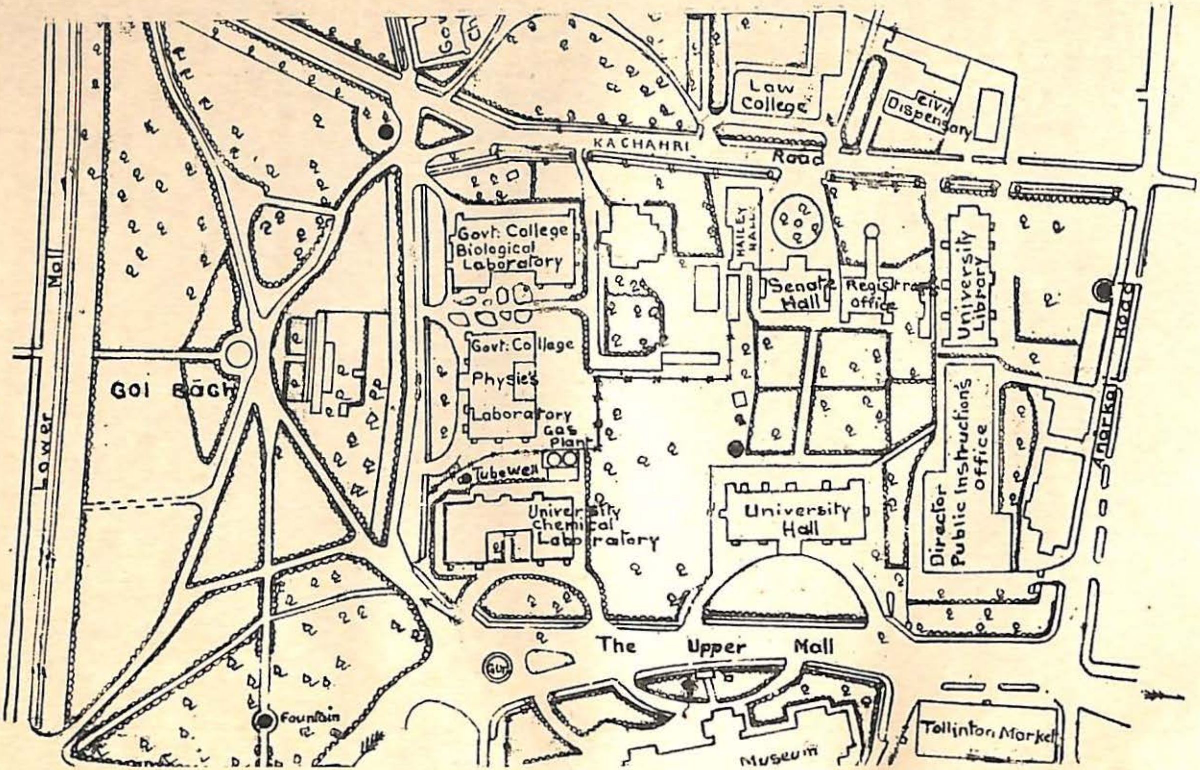
compared with Lahore Colleges. Our University has also always given special attention to Oriental learning.

And now a word about the beautiful capital in which the Congress is to hold its 14th Session. Some of Lahore's historical vicissitudes and its modern buildings have been described by Mr. Manchanda (Chapter I), whose zeal for its archæology is equalled by his enthusiasm for its civic dignity. Nothing can surpass the climate of Lahore in January, with its crisp bracing cold, its sunny days, and blue skies,—unless the Christmas rains are delayed till after the New Year and gray raw wintry mornings spoil the enjoyment of early meetings, or dreary sunless afternoons and evenings take the edge off the charm of social meetings. From such a fate may the *iqbal* of science shield the 14th Congress !

Our warmest thanks are due to the authors of the papers, which form collectively an epitome of scientific Panjab. I wish also personally to acknowledge the valuable assistance of Dr. Rice and Dr. Bhatnagar, who have looked over many of the proofs. The spelling of Indian names is always a stumbling block in a composite work. We are not even agreed how to spell the Panjab. The University consistently spells it PANJAB, following the Hunterian system, which has been theoretically adopted by the Government. But the Government still remains the Government of the PUNJAB. May it soon become the Government of the PANJAB and earn the blessings of countless orthographical purists !

A. YUSUF ALI.

LAHORE :
*December* 15, 1926.




SCIENCE CONGRESS PRECINCTS, LAHORE.

# CHAPTER I.

## LAHORE, HISTORICAL AND MODERN.

By RAM CHAND MANCHANDA, Esq., Advocate, Lahore.

**Situation.**

Lahore is the capital of the Province of the Punjab and the head-quarters of Lahore district. It is an ancient city and is situated on the eastern (or left) bank of the river Ravi. The river once flowed close by the walls of the Fort (Daulatkhana) and the city, and about the year 1660 threatened its very existence, when a massive embankment extending for some 4 miles along its bank was built. This great engineering achievement proved effectual, and not only was the city saved but the river was diverted two miles towards the north and has ever since shown a tendency to move further northward.

**Name.**

The name Lahore is traditionally connected with Loh, a son of Ram, as Kasur (Kushore), a sister town, is connected with Kush, a younger son of Ram. This name is not peculiar to the capital of the Punjab. There is a Lahore in Afghanistan; another in Peshawar District; another in Hindustan Proper; and a Lohar in the Mewar State of Rajputana. A fort called Lohara gave a ruling dynasty to mediæval Kashmir. The name "Lahore" is a corruption of the name "Lohore." Again Lohore is an abbreviation of "Lohawar." The suffix **Awarn**, with its derivatives "**Awar**" and 'Ore,' means a fort. So the name Lahore is a synonym of Lohkot, Lohgarh, Lohpur, or Lohabad.

**Date of its Foundation.**

The exact date of its foundation it is impossible to discover, as there is no recorded material available. It is not mentioned in connection with the expedition of Alexander the Great, nor in the Geography of Ptolemy. It seems to be referred to, but not by name, in Hiuen Tsang, as a great Brahminical city which he passed on his way from Sangla to Jalandhar about 630 A. D. Strange as it may appear, the city of Lahore is not mentioned by Abu-Rihanal-Biruni though he mentions a Province of Lohawar with its capital at Mahdhokor, but Jaipal and his descendants were described as the Rajas of Lahore. If Tod's chronology is to be trusted Lahore existed in the first or second century A. D., when Raja Kanaksen, the founder of the Mewar family, is said to have migrated from Lohkot. The city may well have existed in the first century of the Christian era, and subsequently decayed, but we need not dwell further on conjectures.

## The Occupation of Lahore by the Ghaznavids.

In the eighth century A. D. a struggle commenced between the forces of Islam and Hindustan. After three centuries Lahore was occupied in 1022, when the sovereignty of **Hind** became extinct, and Lahore was left in the charge of Malik Ayaz, a favourite of Mahmud of Ghazni.

## The Mound of Lahore.

It is said that Malik Ayaz built the walls and the fortress of Lahore miraculously in a single night and his tomb close to the Taksali Gate is still revered by the Mussalmans as the burial place of the founder of Lahore. There are strong reasons to believe that Hindu Lahore lies buried in the extensive mounds between Mozang and Ichhra, popularly known as the graveyard of **Miani Sahib**. One of the gates of the modern city is called **Lohari Darwaza** as it opened in the direction of Hindu Lahore. A careful examination of the structure of the mound reveals the fact that it is an artificial mound gradually heaped up by the accumulated rubbish of centuries, and it has lately yielded two stone sculptures of great archæological value. Both these sculptures are representations of Hindu gods and goddesses, and they were found in a well 50 feet deep in the centre of the mound, which materially confirms the belief.

## History of Lahore.

From the date of its occupation by the Ghaznavids till 1798 Lahore is associated with every Muslim dynasty of Northern India from the Ghaznavids to the Mughals, at times as the seat of a provincial Government, but always as a place of great strategical importance. In 1798, Zaman Shah of Kabul made it over as a fief to Ranjit Singh, who afterwards founded a kingdom of which it was the capital. It has remained the capital of the Punjab after the British annexation in 1849.

## Greatness and Importance of Lahore.

Historians and poets both of the East and of the West have united in celebrating the greatness and eulogizing the splendours of Lahore. In the 14th century it was "a city great among the cities of India;" in the 16th century it was "the great resort of people of all nations;" and in the 17th century "the magnificence of its palaces, the length of its streets and the height of its buildings compared with those at Agra and Delhi, and as a city it was second to none either in Asia or in Europe with regard to size or population."

## Decline.

Then there came a change. It began to take its downward course with the decline of the Mughal Empire and it crumbled to

ruins with the fall of the Mughal dynasty. In the year 1664 A.D. Bernier noticed that "the houses had begun to look dilapidated, and the long busy streets of the city to be disfigured with ruins." When Ranjit Singh occupied it "the ruins of Lahore afforded a melancholy picture of fallen splendour. Here the lofty dwellings and Masjids which, 50 years ago, raised their tops to the sky in pride were crumbling into dust, and hardly any human beings were to be seen among the ruins : all was silence, solitude and gloom." Sir John Lawrence wrote in 1852 : "The vicinity of Lahore is an area of several square miles over which extend the ruins of not one but of several successive cities of various eras and various dynasties. The surface of this extraordinary plain is diversified by mounds, kilns, bricks, stones, broken masses of masonry, decaying structures, hollows, excavations and all the debris of habitations that have passed away."

**Modern Lahore.**

This pathetic tale of decay has a sequel. The modern history of Lahore is one of steady development and growth. Splendid new buildings have been erected and some of the beautiful old ones have been restored. Lahore is one of the show places of India to-day. Let us now take a bird's-eye view of Lahore as it is.

It is not only difficult but almost impossible to over-estimate the importance of the part which the Punjab and consequently Lahore has played in influencing the destinies of Hindustan. Lahore covers an area of some 29 miles, and the distances within its area are considerable. The sights of Lahore are found on both sides of the river. The places of modern interest are mainly on the left bank. On the right bank, at Shahdara, are the three great historic tombs, and the beginnings of a new industrial city.

**Shalamar or Shalimar Gardens.**

The foundations of these world-renowned terraced gardens were laid by Shahjahan. They were completed in 1637 at a cost of six lakhs. Originally there were six compartments, with pavilions, marble buildings, and fountains, tastefully and symmetrically arranged, in the midst of trees and lawns. The first terrace, entitled Faiz Bakhsh, was exclusively reserved for the Emperor and the Imperial ladies, and contained his sleeping apartments, baths and fountains. It was in this garden that the Emperor held his gorgeous Imperial Darbars, and the place was guarded by Tartar and Armenian soldiers. It was death to a man to approach the enclosure walls or peep in. Now it is a very well kept garden. It is public property and accessible to all. It is at a distance of about five miles towards the East along the Grand Trunk Road towards Amritsar. It was formerly situated along the banks of the Ravi,

and there was an underground passage connecting this Pleasure Garden with the Palace. Between the Garden and the Palace there was a regular line of gay gardens and pleasure houses that the great nobles had built in imitation of their Imperial Master. The ruins of some of these old sites of Mughal Lahore are still visible.

**The Railway Station.**

The station was built in brick at a cost of Rs. 1,57,000 when the Railway line was first opened in the Punjab in 1862 between Lahore and Amritsar. It was designed to serve as a fortified place in time of need. The requirements of the Railway have outgrown the present buildings, and proposals are on foot for extensions and modifications to meet the growing wants of passenger and goods traffic.

**Railway Workshops.**

The Railway Workshops are the largest and most up-to-date in India and cover an extensive area in continuation of the station yard towards the east between the Railway line and the Grand Trunk Road.

**The Fort and the Palace.**

They are situated towards the north of the city. The Fort was originally built by the Ghaznavids, but the modern structures are entirely the work of the four Mughal Emperors, **viz.,** Akbar, Jahangir, Shahjahan and Aurangzeb.

**The Badshahi Mosque.**

This beautiful building was erected about the year 1674 for the Emperor Aurangzeb by Fidai Khan Koka and is a part of the Fort and Palace. It is the last architectural monument of the Mughal period.

**Ranjit Singh's Samadh (Tomb).**

A curious mixture of Hindu and Muslim notions of a Samadh and a Maqbara. It is situated quite close to the Fort; and there lie the ashes of Maharaja Ranjit Singh, his sons Kharak Singh and Naunihal Singh, and some of the Ranis who became **Sati**.

**Hazuri Bagh.**

The Hazuri Bagh lies between the Fort and the Badshahi Mosque. This is a well laid out garden. In the centre is an elegant marble pavilion called the Baradari, built by Maharaja Ranjit Singh, who transacted State business here.

**Shahdara.**

The Shahdara gardens owe their existence to the tomb of Jahangir raised by his devoted widow Nur Jahan. The great Emperor expressed a wish when on his death bed at Rajauri, on the Bhimbar-Kashmir road, to be buried in the gardens of Nur Jahan. This mausoleum is a fine specimen of Mughal architecture and is situated on the other side of the river, about four miles from the city. The garden was laid out by Nur Jahan and the mausoleum built in the centre in the year 1608.

**Mausoleum of Asaf Khan.**

This celebrated tomb, now shorn of its sumptuous magnificence, lies to the west of Jahangir's tomb. Asaf Khan was a brother of Nur Jahan and the father of Mumtaz Begam of Taj Mahal fame. He was also Jahangir's minister. The monument was erected about the year 1642. Maharaja Ranjit Singh stripped off the white marble of this beautiful building.

**Rauza (Tomb) of Nur Jahan.**

Nur Jahan designed and supervised the erection of the Rauza. It is now situated close to the tombs of her brother Asaf Khan and her husband Jahangir. Nur Jahan died in the year 1638 at the age of 72, and her remains rest here. Beside her sleeps her only child Ladli Begam, daughter of Sher Afgan and widow of Prince Shahryar. Originally the interior of the mausoleum was entirely composed of white marble with delicately coloured floral designs in mosaic. All this wealth of ornamentation was stripped off by Ranjit Singh.

These three Mughal buildings were built in the elegant gardens of the Empress Nur Jahan.

**Baradari of Mirza Kamran.**

The right side of the river was in Mughal times ornamented with beautiful gardens, pleasure houses, and mausolea. The river then flowed through beautiful gardens and elegant buildings for a number of miles ; and no other river in the world could boast of greater Imperial attention than the Ravi. A little lower down were the extensive gardens of Mirza Kamran, brother of Hamayun, and in the centre of these gardens on the right side of the river there was built a pavilion known as the Baradari. It is still standing on the bank of the river, undermined and dilapidated by the encroachments of the river. This seems to be the oldest specimen of Mughal architecture in Lahore. Mirza Kamran received as his portion the Punjab along with Kabul and Kandahar. Besides the Baradari he built a palace in the middle of a garden on the left side

of the river, at a cost of nine lakhs of rupees, from which it received the name of **Naulakha**. No trace of the garden or the palace is left now, but the name survives in the locality near the Railway Station. Kamran may be said to have been the father of Mughal architecture in Lahore.

**Tomb of Anarkali.**

This is another specimen of Mughal architecture erected by Jahangir alongside the old river along what is now the Multan Road, in honour of a beautiful girl in the **harem** of his father Akbar. Anarkali (Pomegranate Blossom) was a pet name of Sharaf-un-nisa, otherwise known as Nadira Begam. The central building is used as the Historical Record Room, but the Cenotaph at the east end, in pure white marble, is one of the gems of Lahore architecture. While Anarkali died in 1599, this monument, as the resting place for her remains, was erected in 1615. In the neighbourhood of this building are the offices of the Punjab Government, those of the Financial Commissioner, and the Council Chamber for the Reformed Legislative Council.

**Chauburji.**

Chauburji, an isolated arched gateway, stands still lower down along the Multan Road, and marks the site of the famous gardens of Zeb-un-nisa Begam, the talented daughter of Aurangzeb. The gardens have all been washed away by Ravi floods, but the gateway with its beautiful glazed tiled-work still stands as a ruin. On the completion of the gardens they were given away by the Princess to Mian Bai, the female Superintendent of the gardens, and the fact of the gift stands recorded on the main archway. Zeb-un-nisa's tomb is shown lower down the road, in the village of Nawankot, but its authenticity is doubtful.

**The City.**

The walled City of Lahore is a trapezium in shape, with the Fort and the Badshahi Mosque on its northern side. It is about a square mile in area and is one of the most congested cities in the world, with narrow lanes and insanitary buildings. The extension of the population east and south is, however, on more modern lines. In the last census Lahore (including Cantonments) had a population of 281,781. It is a growing city and in 40 years its population has increased by about 80 per cent. With the Civil Station it covers an area of about 30 square miles.

The general aspect of the walled city from without, except on its northern front, is not imposing, nor does it lay any claim to regularity or symmetry. Within the City there are no Hindu architectural remains or historical buildings. There are a few

specimens of Pathan buildings, but Mughal architecture is the pride of Lahore. Entering by the Dehli Gate from the east, you come upon the **Chauk**, and the mosque of Wazir Khan which was built in 1634. He rose to the position of Governor of Lahore. This building presents some of the finest specimens of arabesque designs to be seen in Lahore.

Not far from this mosque there is another mosque, of a much later date, built by Bikhauri Khan in the year 1753, with gold plated domes, from which it is popularly known as **Sunehri Masjid** or the Golden Mosque.

**The City Wall.**

It was erected by Akbar and surrounded by a moat on three sides and later on improved by Maharaja Ranjit Singh. After the annexation the moat was filled up to make room for the gardens which now encircle the city, and still later the wall was pulled down to allow the access of fresh air to the city. The city wall was pierced by 13 gates. These still remain, though they were re-built after the annexation. Of these the Lohari Gate is the one that opened in the direction of the Hindu city of Lohawar to the south. The Hindu city lies entombed in the mounds of the extensive graveyard known as Miani Sahib and lately (on the 25th February 1926) it yielded two sculptures of great archæological interest which have been deposited in the Central Museum.

**Modern Buildings.**

The Colleges of Lahore will be described in the following chapter. The University buildings form a compact group. The University Hall, where Convocations are held, is well situated, facing the Mall and flanked by the University Laboratories on one side and the offices of the Director of Public Instruction on the other. Behind this, on a road not quite so presentable, are the University Library and the University Offices, with the newly built Hailey Hall, in which the meetings of the Senate are held. The High Court is housed in a building worthy of the dignity of the highest Court of the Province. The Government House stands on the site of an old Mughal tomb. The hospitals will be referred to in connection with the Medical College (Chapter XI). The Town Hall is situated in pleasant surroundings in the Gol Bagh. The Central Museum close by has a fine collection of coins and of Gandhara sculpture. The Cathedral is a notable red-brick Gothic building.

**Gardens.**

Besides the Shalimar Gardens and the gardens attached to the Tomb of Jahangir across the river, there are three gardens close to centres of population. One is the garden skirting the Circular

Road, which occupies the site of the old moat round the wall of the city, and forms a lung for the city population. Then there is the Gol Bagh, round which are grouped the Town Hall, the Museum, the Mayo School of Art, the University Hall, the University Laboratories, and the Government College, a fine group architecturally, but exhibiting neither unity of style nor design. Finally there are the Lawrence Gardens, covering an area of 157 acres, situated right in the centre of the Civil Station. In this are situated the Gymkhana Club, the Cosmopolitan Club, and other clubs, as well as the Botanical and Zoological gardens.

**The Mall Road.**

This is one of the most picturesque as well as beautifully kept roads in the whole of India, and Lahore is just proud of it. The Upper Mall is skirted by palm trees, and a well kept footpath on one side and a ride for equestrians on the other. It passes the Aitchison Chiefs' College, the Punjab Club, Government House, and Nedou's Hotel on the right, going towards the city, and Lawrence Gardens on the left. After this come the fashionable shops. Lower down on the left are the handsome High Court Buildings and the General Post Office. Further on we come to the Gol Bagh and the University precincts which have already been described.



GOVT. COLLEGE, LAHORE.

# CHAPTER II.

## LAHORE COLLEGES.

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BY A. S. HEMMY, ESQ., B.A., M.SC.,

PRINCIPAL, GOVERNMENT COLLEGE, LAHORE.

The Punjab, as a late entrant into the British Empire, naturally made a later start in modern education than the order provinces of India, and that too was made amongst a population less alive to its advantages. It had, however, made a commencement before India had arrived at the University stage of education, so that it was not very many years after the foundation of Calcutta University before the Punjab opened a college, the Government College, to train students for degrees. This was in 1864, and the first permanent Principal, Dr. Leitner, who arrived towards the end of that year, ruled the destinies of the college for 22 years. The college, housed in a *kothi* inside the city was not taken much advantage of at first, and for five years, even with the somewhat dominating personality and strenuous energy of its Principal, attendances barely reached double figures. From that day its progress has been steady and even the opening of its many sister colleges has not led to any diminution of its numbers. In 1870 Dr. Leitner, a man of many ideas, who had been long agitating for independence from Calcutta, succeeded in founding the Punjab University College with powers to grant diplomas, of which the special feature was that Western knowledge and science were to be taught through the medium of the vernaculars and special emphasis was to be laid on the Oriental classical languages. This idea, excellent in theory, never throve in practice, and the Oriental College, as it became when its diploma granting powers were taken over by the Punjab University on its foundation in 1882, has only existed in actual performance as an institution for instruction in Oriental classics and vernaculars.

With the foundation of the independent Panjab University, colleges, mostly under the aegis of various religious communities, began to spring up apace. The first to start was the American Presbyterian Mission, which founded the Forman Christian College in 1886. This society had, indeed, opened a college in 1866, but evidently felt the attempt premature, as this was closed down in 1869. The Arya Samaj followed in 1889 with the Dyanand Anglo-Vedic College, commonly known in the breath-economising Anglo-Indian fashion as the D.A.-V. College . Then came the foundation of the Islamia College in 1892 by the Anjuman-i-Himayat-i-Islam, and after a long interval a trust under the auspices of the Brahmo Samaj, operating an endowment of the late Sardar Dyal Singh

Majithia, founded the Dyal Singh College. In 1916 the Sanatana Dharma College commenced its classes and at the time of writing the Dev Samaj had received sanction for opening an Intermediate College. All the other colleges provide instruction as far as the Master's degree in one or more subjects.

Women's Colleges first came into being when the Kinnaird College, also under the auspices of the American Presbyterian Mission, added University classes in 1913, whilst the Lahore College for Women, maintained by Government, opened in 1922.

In addition to these Arts and Science Colleges, we have the Central Training College, established in 1881, with the Model School attached, under the control of the Director of Public Instruction, the King Edward Medical College, also a Government institution, which, as a Medical School, was established as far back as 1860, and the Law College, founded in 1870 as a branch of the Panjab University College and maintained now by the University, whilst the Veterinary College, although not affiliated to the Univeristy, is a well equipped institution maintained by Government, granting its own diplomas. These colleges which hold classes for 6,000 students represent a great concentration of University life in Lahore, indeed a great concentration within Lahore itself, for with the exception of the Islamia, the Dyal Singh, the Sanatana Dharma and the Women's Colleges, all are located within an area about half a mile each way with the University buildings in the centre and nowhere separated by a 100 yards from another educational property. Of these the most central is the Convocation Hall, situated on the Mall, near where the *Zamzama* records the invasion of Ahmad Shah Durrani, a handsome edifice in Moghal style, designed by a Punjabi Architect, S. Ram Singh, S. B., C.I.E., who is also responsible for the Museum opposite. To the west of the Convocation Hall and also on the Mall comes the red brick facade of the University Chemical laboratories, whilst on the east runs the low line of the offices of the Education Department. This modern frontage conceals a barrack which is the only remaining relic of the cantonments which in pre-annexation days was located in Anarkali.

Behind the Education offices, in Kacheri Road, is the University Library, a lofty two-storey building in Moghal style, housing nearly 60,000 books. To the west is the Senate Hall built by the Nawab of Bahawalpur on the foundation of the University with a recent addition called the Hailey Hall. Facing this is the Law College, a building in an interesting Hinduised style, behind which is the Oriental College with the Maynard Hall linking the two.

To the west lies the Government College standing on an elevation which in the dead level of the Punjab plains may almost be dignified with the name of an eminence, a Gothic structure overlooking the Anarkali gardens, which in spite of the defects of a period (1870-75) when distinguished architects did not patronise the Punjab, yet, with its church-like spire and prominent verandahs

has an impressive appearance. Indeed, thanks to the said "eminence," wherever a distant view of Lahore is to be obtained, this college is the most conspicuous feature, and correspondingly the view from the north-west tower is very extensive and worth seeing. Linking this building with the University Chemical Laboratory, a quarter of a mile away, come the three Government College laboratories, Chemical, Biological, and Physical ; the architecture of the last two may be called Byzantoid, if not bizarre. A certain amount of conjoint teaching under the direct auspicies of the University is carried on. In Arts subjects this is conducted partly in lecture rooms provided by the University in the Library buildings or elsewhere, partly in College lecture rooms. The University with the assistance of the various colleges conducts Honours School Classes in certain Arts subjects and also maintains the commodious University Chemical Laboratory where the Chemistry Honours School mostly works. The Honours Schools in Zoology and in Botany are conducted by the Government College on behalf of the University in the neighbouring laboratory. In the Government College grounds may also be noted the two hostels, the older one, a large "Quadrangle" accommodating 181 students, and the New Hostel, a handsome three-storey structure designed by Mr. B. Sullivan, the Government Architect.

Adjacent to this last comes the D. A.-V. College, an extensive range of buildings necessary to accommodate its large numbers, the main building being ornamented with a number of Hindu sikras. In the Library is a collection of interesting Sanskrit manuscripts. A little beyond lies the Veterinary College and Hospital where are very complete laboratories for practical instruction and investigation in animal anatomy and pathology. Returning and diverging to the left from the D. A.-V. College, we soon come to the Central Training College where S. A.-V. candidates as well as B. T. students are instructed and practice upon the scholars of the Model School in the same compound. Skirting the Kacheri we pass the Government College once more and a short walk brings us back to the Senate Hall. Continuing a few hundred yards we see facing us the three-storey hostel, "the Ewing Hall," of the Forman Christian College, a design of Mr. Sullivan's, and to the left a Saracenic building which is the main block of the King Edward Medical College, behind which, extending over a quarter of a mile, are other blocks of laboratories, first the Kapurthala Materia Medica Laboratory, then on the left the Faridkote Anatomy Theatre and on the right an extensive building in Saracenic style, the Bahawalpur Laboratory, housing Physiology, Pathology and Bacteriology. Beyond that are quarters for the hospital staff, and further to the west the College Library, the Albert Victor Hospital for Europeans and Anglo-Indians, and the large Mayo Hospital for Indians with 422 beds, the whole forming one of the most completely equipped establishments in India for Medical Education, erected largely by public subscription as a Memorial to King Edward.

If we had passed to the right of the Ewing Hall in the direction of the Post Office a few steps would lead us to the Forman Christian College, an extensive series of buildings, somewhat crowded together by the necessities of space. Here, amongst other features is to be found a Technical Chemistry Laboratory, where the college conducts classes on behalf of the University. Connected with this is the School of Dyeing and Tanning, a Government institution located at Shahdara. If we now turn up the Macleod Road, leading past the Telegraph Office towards the station, just beyond the Cathedral, the Hall Road leading to the right brings us to the Lahore College for Women, a *purdah* institution, whilst on Nisbet Road, further on to the left, is the Dayal Singh College, Near the Railway station we have the Kinnaird College, whilst between the Railway station and the Medical College on Railway Road, is the Islamia College, an extensive block in Oriental style with various minor blocks.

The Sanatana Dharma College, developed about the nucleus of an old bungalow, is in the other direction about a mile south of the University. Religious instruction according to the principles of the Sanatana Dharma forms a special feature in this institution.

Of educational institutions not connected with the University, special mention may be made of the Maclagan Engineering College, Moghalpura, about four miles away on the Grand Trunk Road between Lahore and Amritsar. This is a Government institution providing instruction in Mechanical Engineering. By arrangement with the authorities of the North Western Railway who have a share in the management, workshop instruction is given on alternate weeks in the enormous Railway Workshops which are not far off. The students are of two classes, the bulk are trained to take subordinate positions in the Railway Workshops, where a certain number of appointments are guaranteed, whilst a limited number undergo a more extensive course to fit them to become Mechanical Engineers.

Another outlying institution is the Aitchison Chiefs' College where amidst extensive and well planted surroundings the scions of the "Golden Book" have every opportunity of improving their minds and bodies. The grounds, which are well worth a visit, lie on the road to cantonments. A corresponding institution on the feminine side is the Queen Mary College, but that is exclusively *purdah* and so is inaccessible save to wives of members of the Congress.

If we return to the University area we find, exactly opposite the University Chemical laboratories, an interesting place, the Mayo School of Arts, where in addition to art classes, special attention is given to training in and perfecting of the various artistic crafts of the Punjab.

Scattered in all parts of the city and its environs are schools of all grades, too numerous to individualise, a further instance of the concentration of education upon Lahore. This concentration may in part account for the special attention given in this province to hostel accommodation and life. Quite half the students in Lahore come from outside, and every college has attached to it and under its direct control a number of hostels, often huge buildings, and in addition there are other hostels, maintained mostly by different communities, which are inspected and licensed by the University. The ideal of the University, which arrives very near attainment, is that no student shall live, when dissociated from his parents or guardians, in private lodgings. The Colleges have also attached to, or detached from them, large playing fields, the most important of which is the Chauburji ground, an extensive triangle a mile to the south of the University, owned partly by the University and partly by the Government College, where the University Tournaments are held, often amidst scenes of great excitement.

On this ground is situated the University Astronomical Observatory, housed in two small buildings, one for the transit instrument, the other for a 7-inch equatorial.

The social life of the students is mainly centred on the colleges, but mention may be made of the Y. M. C. A. Hall, opposite the Forman Christian College, where, in addition to instruction in various commercial pursuits, gatherings are held and lectures on every kind of topic are given.

Another educational movement of which mention should not be omitted is that due to the Society for Promoting Scientific Knowledge, a society founded by University students and largely fostered by members of various collegiate staffs. This society aims at promoting a knowledge of hygiene and infant welfare amongst the masses of the population and has branches all over the Punjab. It has its centre near the Mori Gate of the city in the S. P. S. K. Hall.

# CHAPTER III.

## SCIENCE TEACHING IN LAHORE.

By BERNARD HOWELL WILSDON, Esq., M.A., B.Sc., (OXON), I.E.S.

Any attempt to give an account of the development of Science teaching in Lahore in the space available for this article must necessarily be sketchy. It is not proposed to give a complete guide to the laboratories of Lahore or to trace their individual histories. It will be enough if some idea can be conveyed, without too statistical a presentation, of the present capacities of the capital of the Punjab for the higher teaching of the sciences and their development and organisation. Such a task is not easy and the result is likely to be dull reading. It must also be far from complete, so the writer apologies in advance if any features of the scientific organisation of Lahore have been left unmentioned which may appear to those concerned to have merited more consideration.

The foundation of any school of science is necessarily the elementary teaching. Here, as in other provinces of India, students accepted in the Intermediate Science course have received a modicum of scientific training in the schools. It is, however, not uncommon for students with no previous acquaintance with the fundamentals of the sciences to take up a science course in the Intermediate. Yet in 1924, 6,097 students offered science in the Matriculation Examination. Of these 1,447 proceeded to science courses in the Intermediate, and appeared for examination in 1926. During the last decade the total number of students appearing for Matriculation has trebled. In the same time the number of students offering science has increased 3·17 times.

It may first be profitable to explore the various avenues by which the matriculate can advance to the higher realms of science. He may take an Intermediate Course comprising Physics, Chemistry, Botany and Zoology at several colleges in Lahore. The Mofussil Colleges also contribute to the rarefied stream which, by a complicated process of selection, natural in the case of scholarship-holders, more accidental with others, proceeds to the higher degrees. At this stage several alternatives are open to the science student. The majority will proceed to a pass degree either in the Arts or Science Faculties. A select proportion may gain admission to one of the Honours Schools, or join the Medical, Agricultural or Engineering Colleges.

**Pass and Honours Courses.**

The Pass Course is a two years' course which can be followed by the M. Sc. Course in the same subjects. In 1915 a change was made in the conventional M. Sc. Chemistry course by requiring

the candidate to offer a thesis embodying research work in place of one of the theoretical papers previously demanded. With the introduction of the Honours degrees in Chemistry and other subjects, which require a three years' course of study, the research work has been wholly relegated to the M. Sc. stage which will now only be open to graduates of the Honours Schools. This reform should have beneficial results on the teaching of the sciences in which it has been adopted. Thus the fundamental theoretical work will be all given during the three years' B. Sc. course. By that time the student should be fit for specialisation and can then proceed to his M. Sc. degree by offering a research thesis. It is hoped that by 1929 the old M. Sc. course in Chemistry and other subjects will have disappeared, as it has already done in Zoology. The avenue to the highest degrees in pure science will then be by way of a three years' Honours Course, followed by research for the M. Sc. degree.

The number of students for whom such a degree is possible is at present as follows :—

| | | |
|---|---|---|
| Honours Chemistry | .. | 20 |
| " Botany | .. | 7 |
| " Zoology | .. | 5 |
| " Technical Chemistry | .. | 12 |

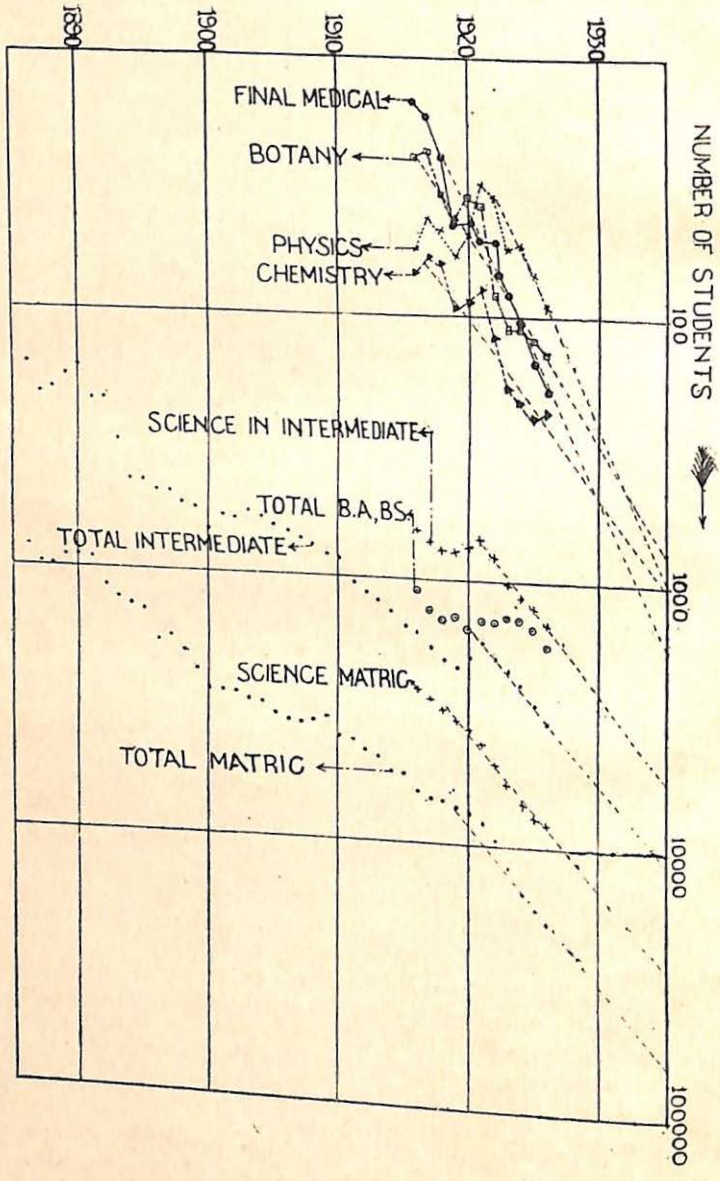
It will thus be seen that ample provision exists at present in the Province for the teaching of students who are likely to apply their scientific knowledge directly. The extent to which such application has until now been made, either by research in pure science, or applied to the requirements of the Province, will be reviewed below. It will first be of interest to form an estimate of the general scientific training not directly applied. It is an article of faith of the teacher of science, and now-a-days of the employer that it is the general spread of such a training by science teaching which plays the most important part in creating the modern state.

Such a claim will perhaps not be admitted by all educationists, and the philosopher may object that modernising is not an end in itself. But the keynote of the modern spirit is a striving for mastery of the forces of Nature. Science has amply demonstrated its power, so that the educated man learns no longer to accept conditions with unenquiring fatalism in which he finds himself, but will demand an analysis, even if no practical solution results therefrom. The power to analyse or synthesize may be for the few, but a general appreciation of the processes by which knowledge may be gained is as valuable in the community as the will-to-know in the individual. In fact the will-to-know must exist in every individual of the modern state, even if he does no more than pay in taxes for the up-keep of those who carry on the enquiry.

The popularity of Science in the educational organisation of the Province is one of its most remarkable features. Very nearly



UNIVERSITY CHEMICAL LABORATORIES, LAHORE.



NUMBER OF STUDENTS
100
1000
10000
100000
1890
1900
1910
1920
1930
FINAL MEDICAL
BOTANY
PHYSICS
CHEMISTRY
SCIENCE IN INTERMEDIATE
TOTAL B.A, BS.
TOTAL INTERMEDIATE
SCIENCE MATRIC
TOTAL MATRIC

half the candidates appearing in the Intermediate offer Science. This cannot be from motives, so frequently attributed, of selecting the easy subjects, since a combination of four science subjects, involving long hours of practical work, is undoubtedly the most exacting course for the mere degree hunter. The popularity of Science can be nothing more than a genuine and healthy symptom of a determination to master all the vehicles for progress offered by modern scientific knowledge. This can be seen by reference to the curves printed in the diagram. In this the number of candidates appearing for examinations of the University is plotted on a logarithmic scale against the times. These show some remarkable features. It is unfortunate both from the purely æsthetic point of view of the regularity of the curves, as well as from their results on the progress of education, that political disturbances due to the Khilafat Non-Co-operation movements are very markedly exhibited. Since 1921, however, there has been a very steady increase in all subjects. If we can rely on an extrapolation, the Matriculation and Intermediate classes are expanding exponentially at a rate which will lead to 100,000 Matriculates and 10,000 Intermediate students annually. The proportion of science students to the total is well maintained, over half taking Science in both classes. The B. Sc. Science classes show the most rapid increase. If an extrapolation is warranted, which the writer does not believe, their size will soon become something of an embarrassment to the Province. The provision of laboratory accommodation for well over 1,000 students a year in each of the science subjects is a prospect before which our educational financiers may well quail. But the steady growth of the science students in comparison with the total number of students studying for the Bachelor's degree can only be a matter for congratulation. The practical applications of science may not demand this increasing volume of students but the wide spread of its discipline can have only beneficial results.

We must now regard the main function of our pass science courses in the light of this more general aim. The needs of the scientific specialist are being provided for by the Honours Courses. For every twenty B. Sc.'s who take the Honours Courses in any year, there must be considered in the scientific life of the Province over 500 who take a science subject in a Pass Course. It is obvious that with a more generalised objective in scientific teaching, when the educational idea is of more importance than the purely utilitarian aim of turning out a well grounded specialist, the conventional course may be extensively modified and improved. This process is now actively engaging the attention of the Boards of Studies of the University.

**The Honours School of Chemistry.**

The scheme for the Honours School in Chemistry providing for the concentration of higher teaching under the University with the co-ordinated assistance of the constituent colleges, followed on

a visit of Prof. A. Smithells, F.R.S. The detailed scheme was largely worked out by the writer of this article, who also prepared rough plans of the proposed building. This was constructed in 1923-24 on a site provided by the Government. The cost, including equipment, was Rs. 4½ lakhs, of which Government provided Rs. 3 lakhs. The building, which is architecturally one of the finest modern buildings in Lahore, and in equipment and scientific amenity, one of the best in India, was constructed from the plans of Mr. B. M. Sullivan who was aided by a Scientific Committee consisting of Prof. H. B. Dunnicliff and Prof. B. Kartar Singh. In October 1924 Dr. S. S. Bhatnagar was appointed University Professor, since when the laboratories have rapidly filled with students. In fact, the accommodation available is already too small to cope with the demands for admission. The teaching staff of the Chemistry school includes Dr. Dunnicliff, under whom part of the practical course is carried out in the recently extended laboratories of Government College. Prof. Yajnik of the F. C. College and Dr. Krishna, the University Lecturer in Organic Chemistry, are also associated in the teaching work, an essential point of the Honours School Scheme being that Professors of the Colleges of the University should be associated in the higher teaching and research work.

**Research work in pure Chemistry.**

Research is either the product of the isolated man with leisure, or of a school, school being used in the sense of a teaching organisation, the students of which can be initiated in the methods of original work, under the guidance of an experienced worker. In the early days of science, in Lahore as in other University Centres in India, the unfortunate teacher was frequently expected to give instruction in Physics and Chemistry as well as possibly a little English and Mathematics, to both elementary and higher classes. It is not surprising that under such conditions little original work could be produced even by men who had already displayed aptitude and ability in their post-graduate days. With a central organisation co-ordinating the teaching of a science in its higher branches, more leisure is available for teachers, who previously may have been giving instruction in every branch of an identical course in neighbouring institutions. The beginnings of research in Chemistry date in the Punjab from the time when staffs were increased, and students were required to offer a research thesis for the higher degrees. Under Dr. Bhatnagar at the University Chemical Laboratories, an imposing series of papers, mainly on colloidal subjects has been published, many of the results of which are already incorporated in text books of that rapidly developing branch of science. The Government College and Forman Christian College laboratories have similarly to their credit a growing series of scientific publications mainly carried out under the Professor concerned, by M. Sc. students engaged on thesis work.

**Technical Chemistry.**

The last addition to the list of Honours Schools has been made this year, by the taking over of the Forman Christian College Technical Chemistry Laboratory by the University. The organisation of this department has been entirely the work of Prof. P. Carter Speers. Starting in 1917 from modest beginnings, Prof. Speers will now have the satisfaction of seeing his laboratories expand and serve an increased field of usefulness as the result of extra funds provided by the University. The equipment includes modern machinery for soap making and pottery, on a semi-commercial scale, as well as sugar and oil machinery, with facilities for research in these and allied subjects. The University Honours School Course involves work by the students in the F. C. Physics Laboratory, the Maclagan Engineering College, the Government Tannery and Dye School at Shahdara and other factories. The varied nature of the course with its periodical qualifying examinations in subsidiary subjects such as Physics, Mathematics, Engineering and Economics, should ensure the turning out of men well qualified to apply their chemical knowledge in commercial pursuits.

**The Honours Schools of Zoology and Botany.**

The institution of the Government College Biological Laboratories will always be coupled with the name of Colonel Stephenson, at one time Principal and Professor of Zoology. These laboratories serve the double function of providing for the teaching of biology for Government College students in the F. Sc. and B. Sc. Pass Courses, as well as furnishing accommodation for the University Honours School Classes. The building was erected at a cost of about Rs. 2 lakhs and was opened for work in 1914.

Recently an extension of the building has been sanctioned by Government and is now in progress. The cost of the maintenance of the laboratories and staff is discharged partly by Government and partly by the University.

The organisation of these classes was started about the same time, and corresponds almost exactly with those of the Chemistry School. The record of research work turned out by the laboratory and, in particular, the proportion of zoological work carried out in India as a whole by old students must be a matter for keen pride both to the founder of the laboratory and its present head. Prof. Matthai now has all the accommodation in his laboratory filled with research workers, by whose efforts, under his guidance, a systematic survey of the fauna of the Punjab and Sindh is progressing. The work is being published in a connected series of memoirs. Work on morphology and cytology as well as Professor Matthai's authoritative review of the coral fauna of the world is also in progress. Professor Diwan Anand Kumar, the representative of the University in the Department has been doing excellent work in the

" Tetraxonid Sponges in the Collection of the Indian Museum, Calcutta."

Professor Shiv Ram Kashyap, who has been in charge of the botanical side since its formation, has contributed a long series of papers mainly on the structure distribution of Himalayan Liverworts and some Pteridophyta and Gymnosperms. Dr. Chaudhree, the University Reader, has worked mainly on Mycological subjects and Algae. The varied subjects investigated by other workers as well as by students for theses would be too diverse for mention here.

As regards pure biological work carried out in Lahore it will be sufficient to conclude by saying that the patriotic duty of thoroughly investigating the local flora and fauna is being energetically pursued, in addition to the work on the more fundamental aspects of the science.

**Applied Science.**

Mention must be made here of the relation between the pure sciences so far dealt with and their applied forms. The connexion between such applications and the teaching and research in the pure sciences is worthy of mention. Co-operation between various departments in work on the borderland dividing the sciences is of the first importance in the scientific life of a University. The Medical College with its paramount duty of training an adequate army of medical practitioners for the care of the health of the province is also concerned with research, for which it is splendidly equipped. From the Medical College Physiological Laboratories Major Hughes has contributed several papers on the influence of drugs on metabolism. Collaboration between the physical chemist and the biologist is worthy of note in some interesting work on polarised radiation and bacterial growth by Dr. Bhatnagar and Dr. R. B. Lall.

The Irrigation Research Laboratory which has been instituted recently for work in connection with problems arising from irrigation, such as waterlogging and hydrodynamical questions, is at present housed in a wing of the University Chemical Laboratories pending the building of a specially designed laboratory in the vicinity. Medico-legal work is carried out by the Chemical Examiner in another laboratory near the jail. A scheme for the institution and equipment of a Government Industrial Laboratory is now under consideration.

**Libraries.**

A complete library of periodicals is perhaps the most important factor in enabling an unhampered development of research in any science. In Lahore the University library is the nucleus; by co-operative arrangement with private laboratories the important journals of most learned societies are available in one or other of the libraries, although much money may still have to be spent in obtaining complete sets.

**Scientific Societies.**

The Lahore Philosophical Society is the oldest scientific society. It was founded as an "Omnibus" society for the discussion and publication of papers. With the specialisation now prevalent in all sciences, the utility to all members of detailed discussions is reduced, so that we find the most vigorous life in newer societies dealing with one subject only. Notable among these is the Lahore Branch of the Indian Chemical Society. This society has 91 members and has collected a research fund for the assistance of post-graduate students. At this moment five research students are in receipt of stipends from this fund.

In concluding this cursory survey it is very satisfactory to be able to point to the vigorous life and the ample scope for expansion in all branches of science. Without the sympathetic encouragement of Government, and some generosity in financing the development of science in this comparatively young country, side by side with the capacity and application of the workers recruited in this field, no rapid advance will be possible. Luckily neither of these essentials is lacking.

# CHAPTER IV.

## DEVELOPMENT OF IRRIGATION IN THE PUNJAB.

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### Some Physical Aspects.

In its strict etymological sense the Punjab or the land of the five rivers, is the country enclosed and watered by the Jhelum, Chenab, Ravi, Beas and Sutlej ; though the province as at present constituted includes also the tableland of Sirhind south of the Sutlej and the so called Sind Sagar watershed, the wedge of the country lying between the Jhelum and the Indus. There is with the single exception of Sind, no portion of India which is so favourably situated as regards its rivers or so unfavourably as regards its rainfall as the Punjab Proper. By far the greater portion of it has a rainfall of less than 15 inches a year and much of it less than ten. But rainfall in the catchment areas of all the five rivers is over 25 inches a year.

### Punjab before Annexation.

Before annexation in 1849 there were no communications worthy of the name. The bad condition and insecurity of the roads and the levy of vexatious transit and customs dues prevented exportation of grain to any distance and the people of one tract starved for food while plenty reigned in neighbouring districts. Supplies could only be sent up to the affected areas by country carts at the rate of ten miles a day. The produce of the soil was formerly dependent on a short and erratic rainy season. Accordingly famine was the inevitable accompaniment of these economic conditions which left the bulk of the people dependent on the soil for their means of livelihood. The province was visited by a disastrous famine in 1783. During the first 40 years of the nineteenth century six famines of greater or less severity occurred in 1802, 1812, 1817, 1824, 1833 and 1837, out of which those of 1812 and 1833 were almost as severe as that of 1783.

### Early Efforts at Irrigation.

Before the advent of British rule, there were a few canals and tanks but there were no large scientific works. About the middle of the 14th century Ferozshah Tughlak built a canal to supply water to his hunting grounds at Hissar. In fixing its alignment, advantage was taken of any natural hollow or channel whose slope and direction were found suitable. Consequently the resulting work took the form of a linked series of drainages rather than of a canal.

The channel silted up, but was renovated by Akbar about the year 1568 and remodelled again in 1626 under the direction of Ali Mardan Khan, the great Engineer of the Emperor Shah Jahan. Also a new branch was added thereto to supply water to the fountains of the Imperial Palace at Delhi.

About the middle of the 17th century, the Moghul rulers constructed a canal known as Hansli from the river Ravi at Madhopur to supply water to the Shalimar and other gardens at Lahore. Later on, during the Sikh rule, a branch from this canal was taken to Amritsar to fill the sacred Sikh tanks there.

In the west of the Punjab, there were a number of inundation canals dug by people with some help from their Muslim and Sikh rulers. The most important of these were the Khanwah and the Upper Sohag Canals. The exact dates of their first excavation are not known but the former was improved in Akbar's time and the latter was first used as a irrigating channel in about 1827. The Khanwah silted up and was cleared again and its head repaired by Maharaja Ranjit Singh. It again silted up in 1823 and nothing seems to have been done for it till 1841 when it was cleared under the orders of Maharaja Sher Singh and a new head dug for it near Kamoki.

**Means of Artificial Irrigation.**

There is no province in India except Sind which stands more in need of artificial irrigation than the Punjab. The real indigenous source of irrigation is the well. But well water exacts at least three times as much duty as canal water. As a rule, well irrigation is not practised where the depth of water is much over 35 feet as the cost of lifting beyond that becomes excessive in comparison with the value of crops. The districts which employ wells most largely are Jullundur, Sialkot, Amritsar, Ludhiana, Jhang, Muzaffargarh, Lahore and Gujranwala.

**Development of the Present Canal System.**

*Improvement in old indigenous works.*—The first efforts of the British Engineers were directed to the improvement of existing indigenous works rather than to the construction of new irrigation projects.

1. The Eastern Jumna Canal was restored by the British Government in 1821 but hardly any improvement in its design or alignment was made at the time. The result was that its embankments offered obstruction to the drainage of rainfall from the ground surface. The canal was remodelled about the year 1880 and a permanent weir across the Jumna was constructed at Tajewala. The Sirsa Branch was added in 1889-95 and the whole system from being a standing reproach is now an unmixed blessing to the country-side.

It commands a gross area of 2·7 million acres in the Ambala, Karnal, Rohtak, Delhi and Hissar districts, and Kalsia, Jind, Bikaner and Patiala States and actually irrigates annually about 830,000 acres. The total capital expenditure on this system at the end of 1924-25 was Rs. 188 lakhs which yielded a net annual direct return of 11·27 per cent.

2. The Upper Bari Doab Canal was one of the first measures which engaged the attention of the British Government after the annexation of the Punjab in 1849. Its construction was a political necessity in so far as the disbanded Sikh soldiery whose homes were in the Bari Doab were to be turned into peaceful agriculturists. The canal was opened in 1859.

It commands a gross area of 1·64 million acres in the Gurdaspur, Amritsar, Lahore and Montgomery districts and irrigates about 1·28 million acres annually. The total capital expenditure on this canal at the end of 1924-25 was Rs. 214 lakhs which yielded a net direct return of 17·6 per cent. during the year.

Certain extensions at the tail of this canal in the beginning of this century brought into existence the Chunian Colony. This area of about 100,000 acres of Government waste was colonised between 1894—1904 entirely from the more congested portions of the Lahore district.

3. *Inundation Canals.*—Another irrigation problem requiring immediate attention on annexation was the improvement of the indigenous inundation canals. Some of them were in serviceable condition while others had been allowed to become choked and useless. Strenuous efforts were immediately made to restore them and to extend their scope. Also several which had been built by private agency were taken over by Government at the owner's request. All these canals with their branches excluding Sidhnai Canal have an aggregate length of 3,900 miles and irrigated 1·93 million acres during the year 1924-25.

**Construction of New Canals.**

The acceptance by the Secretary of State for India of the principle of financing productive works by loans raised in the open market gave a great stimulus to the development of irrigation in this country, and the following were the direct results of this new policy :—

(1) The Sirhind Canal.
(2) The Lower Sohag and Para Canals.
(3) The Sidhnai Canal.
(4) The Lower Chenab Canal.
(5) The Lower Jhelum Canal.
(6) The Upper Jhelum Canal. }
(7) The Upper Chenab Canal. } *Triple Canals.*
(8) The Lower Bari Doab Canal. }

**The Sirhind Canal.**

The first proposal for a canal from the Sutlej river contemplated the irrigation of the Patiala State only, but in 1867 the Government of India desired that the waters of the Sutlej should be utilized to the best possible advantage in the tracts commanded, irrespective of territorial boundaries and the project was revised accordingly and the canal constructed in strict accordance with this principle.

This canal commands a gross area of 4·40 million acres of which about 47 per cent. is British, about 35 per cent. is in the Patiala State and about 18 per cent. in the States of Nabha, Jind, Faridkot, Malerkotla and Kalsia. The annual area irrigated is about 1,100,000 acres.

The management of the Patiala and other State Branches is vested in a British Canal Officer who is responsible for their maintenance and for the distribution of supply between the States. Each State maintains and manages its own distributaries, exercises complete control over the irrigation therefrom and assesses and collects its own revenue.

The total capital expenditure on this canal to the end of 1924-25 was Rs. 262 lakhs, which yielded a net direct return of 12·86 per cent. during the year.

**The Lower Sohag and Para Canals.**

The history of colonization in the Punjab may be said to have commenced in 1882 with the formulation of the Lower Sohag and Para Canal Project from the river Sutlej, some 40 miles below Ferozepore. It is a purely inundation canal and irrigates about 119 thousand acres annually. Of the total area commanded by it nearly half was Government waste land, which was, on the construction of the canal, divided up into 54 villages and allotted to carefully chosen and industrious agriculturists from the adjacent over-populated districts. The work of settlement extended from 1887 to the cold weather of 1888-89 and the experiment proved completely successful.

*The Sidhnai Canal* was constructed at the same time as the Lower Sohag and Para Canals. It was originally projected in 1856 but it was not until 1882 that the proposal was seriously considered. It has its head on the Ravi in the Multan district near Lachhman Kund and Ram Kund and irrigates about 300,000 acres. This system consists of Sidhnai Proper, Koranga, Fazal Shah and Abdul Hakim Canals. The Sidhnai Canal Proper is 37 miles long while the 3 smaller canals have a combined length of 31 miles. From these main lines 384 miles of distributaries are fed.

It is a semi-perennial canal. Its permanent headworks enable it to utilize the whole volume irrespective of the natural surface

level, but it has generally, owing to shortage of supply to remain closed during part of the cold weather. The gross area commanded by this system is 419,848 acres out of which 232,000 acres were Government waste. Colonization began in 1896 in which year the canal was opened and for some time success seemed doubtful but with the arrival of a party of pioneer colonists from the Amritsar district the tide turned. The main work of colonization was completed within 2½ years.

**The Lower Chenab Canal** takes off from the river Chenab at Khanki and commands a gross area of 3·4 million acres in the Gujranwala, Sheikhupura, Lyallpur and Jhang districts. The area annually irrigated amounts to about 2·5 million acres.

It was first opened in 1887 as an inundation canal but in 1892 it was converted into a perennial canal. The total capital expenditure on this canal to the end of 1924-25 was 346 lakhs of rupees and the net return therefrom on account of direct income was 22·29 per cent. on the above amount, but if the indirect income is also taken into consideration the return on capital account works out to about 50 per cent. annually.

Colonization began in 1892 and the first colonists had to suffer much owing to scanty rainfall, lack of roads, etc., but they were soon rewarded for their troubles by an excellent crop and in ten years' time the population of the tract rose from 8,000 to 800,000. A railway for the carriage of produce was commenced in 1895, roads came rapidly into being, and towns and factories began to spring up in the former desert. Lyallpur, which is now an important city, with an enormous export trade owes its birth to this canal.

**The Lower Jhelum Canal** takes off from the river Jhelum at Rasul. It commands a gross area of 1·33 million acres in the Gujrat, Shahpur and Jhang districts and irrigates about 850,000 acres annually.

The original project was sanctioned in 1888, but owing to precedence of construction being given to the Lower Chenab Canal, work on this canal was held in abeyance till 1897. The canal was formally opened in 1901, but the project was actually completed in 1908.

Out of the total commanded area, 568,000 acres were crown waste. Colonization began in 1902 and the opportunity was taken to assist the Remount Department by attaching horse-breeding conditions to the majority of grants. The whole colony is an extremely prosperous one, and the town of Sargodha owes its present prosperity to this canal.

The capital cost of the project to the end of 1924-25 was Rs. 189 lakhs which yielded a net direct return of 11·58 per eent. during the same year.

**The Triple Canals.**

The primary object of this project was the irrigation of the Ganji Bar in the watershed between the Ravi and the Sutlej. Since the whole of the winter volume of the Ravi was already hypothecated to the Upper Bari Doab Canal, the Sutlej naturally appeared the most suitable source of supply to the area in question. A scheme for a canal with its head at Harike on the Sutlej was actually prepared and submitted for sanction, but the Irrigation Commission of 1901 strongly recommended that other means of irrigating the tract in question should be sought, the Sutlej water being conserved for the protection and improvement of the existing inundation canals which draw their supplies from it, and for the extension of irrigation into the unirrigated waste on either bank of the river. As a result of this recommendation the Triple Canals Project under which the Ganji Bar (Lower Bari Doab) is irrigated by surplus water from the Jhelum river transferred across the Chenab and Ravi was designed. The Upper Jhelum Canal takes off from the Jhelum river at Mangla (Kashmir State) and carries its water into the Chenab discharging itself into the latter above the headworks of the Lower Chenab Canal at Khanki. The Lower Chenab Canal is thus fed with Jhelum water and the Chenab water so freed is taken from a new headworks at Merala, 36 miles above Khanki, into the Upper Chenab Canal, the second link of the Triple Canals. This canal runs southward to the Ravi, which it crosses on the level at Balloki. Below Balloki it is known as the Lower Bari Doab Canal.

*The Upper Jhelum Canal* being a feeder canal for the other two of the Triple Canals, commands a gross area of 600,000 acres in the Gujrat district and then annual irrigation therefrom is about 340,000 acres. The capital expenditure thereon to the end of 1924-25 was Rs. 442 lakhs with a net return of 0·74 per cent. during the year.

Many hill torrents of which the most important are the Suketor No. 1, Suketor No. 2, Jaba and the Bhimber, cross the alignment of the canal and were dealt with by means of level crossings, syphons, culverts or inlets as the circumstances dictated.

*The Upper Chenab Canal* irrigates about 611,000 acres annually and commands a gross area of 1·59 million acres in the Sialkot, Gujranwala, Sheikhupura and Lyallpur districts. The total capital expenditure on this canal to the end of 1924-25 was Rs. 368 lakhs on which a net direct return of 3·38 per cent. was received during the year.

*The Lower Bari Doab Canal* commands a gross area of 1·75 million acres in the Lahore, Montgomery and Multan districts and the annual irrigation therefrom is about 1,000,000 acres. The total capital expenditure on this canal to the end of 1924-25 was Rs. 219 lakhs, which yielded a net direct return of 13·27 per cent. during the year.

Each of the Triple Canals was opened as it was practically finished, the Upper Chenab Canal in 1912, the Lower Bari Doab Canal in 1913 and the Upper Jhelum Canal in 1915. The whole work was not, however, fully completed until 1917. Of the total area commanded by these canals, 1,570,000 acres were crown waste and out of this 1,490,000 acres were available for allotment. Colonization has been going on steadily and up to the end of September 1920, 880,000 acres had been allotted, most of the unallotted balance being in the Lower Bari Doab Colony.

**Schemes under Execution.**

There are large areas of land which in the Punjab have not yet been allotted for cultivation. A considerable portion of these areas will be brought under irrigation by the Sutlej Valley Project which is described below.

Smaller areas scattered over the existing canal irrigated tracts are being brought under irrigation by extensions of the existing canals wherever that can be done without detriment to the claims of existing cultivation and these extensions affect a gross area of 303,359 acres.

*The Sutlej Valley Project* is a direct outcome of the great Triple Canals Project as described above. Its object is threefold. Firstly, by the provision of weirs and head regulators it will afford to the existing inundation canals a controlled supply during the Kharif crops rendering them immune from the present detrimental effect of the vagaries of the rivers. Secondly, the areas irrigated by the existing canals have been extended so as to embrace the whole low-lying area in the river valley. Thirdly, perennial irrigation has been provided for the large tracts in the uplands on either bank, in the Punjab on the north and in States of Bahawalpur and Bikaner on the south, these tracts being at present entirely unirrigated and waste.

The scheme consists of four weirs—three on the Sutlej and one on the Panjnad, with eleven canals taking off from above them. It will command a gross area of 8·87 million acres or about 14,000 square miles, and the actual irrigation is expected to cover about 5·4 million acres annually. Of these 2·2 million acres will receive water in both the Rabi and Kharif seasons and 3·2 million acres in the Kharif only. Out of the total irrigable area 2·1 million acres will be in British territory and the remaining in the Bahawalpur and the Bikaner States.

The original Project estimate which was sanctioned by His Majesty's Secretary of State for India in December 1921, amounted to Rs. 14,59,90,433, but owing to the general rise in rates and prices, to the necessity of increasing the flood discharging capacity of the first weir at Ferozepur and to the increased cost of dealing with floods during construction and of pumping, etc., the cost of

the scheme will probably be in the neighbourhood of 50 per cent. in excess of the original estimate. The scheme will still be productive even if judged by the severe standards laid down by Government for the classification of schemes as productive and non-productive.

The Suleimanke headworks are nearly completed and irrigation therefrom has been started from the Kharif of 1926. It is hoped to commence irrigation from the Kharif of 1927, from the Bahawalpur canals, which take off above the Islam weir and to complete the Bahawalpur Canals from the Suleimanke weir by the end of 1929-30. It is estimated that the Ferozepur weir and the Bikaner Canal will be completed by the end of April 1928. Work on the Panjnad weir has just commenced and the weir and the canals therefrom will probably be completed by April 1933.

A notable feature of this great scheme is the introduction of machinery on a large scale. Mechanical excavators of various types are being employed for excavation purposes, while pumps, concrete mixers, etc., driven by electric power generated in large power stations equipped with the most modern machinery are in use at the headworks and elsewhere.

The effects of this scheme will be visible not only in the enhanced prosperity which will ensue in the Punjab and in the States of Bikaner and Bahawalpur but in the food supplies of the world. Nearly 3·75 million acres of desert waste will be brought under cultivation for the first time.

**Schemes under Contemplation.**

The following schemes are under contemplation and if constructed will increase irrigation considerably :—

*The Thal Canal Lesser Project* : provides for the irrigation of the western part of the Thal, *i. e.*, a strip 15 to 20 miles wide alongside the railway line from Kundian to Muzaffargarh. This strip is admitted by all authorities on the Thal as the flattest and most fertile portion of the country. The gross area covered by the project is 2·2 million acres and the culturable commanded area is 1·44 million acres. Of these 264,000 acres are in Government Rakhs and it has been estimated that 696,000 acres will come to the Government under the Sind Sagar Doab Colonization Act when the canal is constructed. The Government will thus have a commanded area of 960,000 acres at their disposal for colonization purposes.

The scheme is estimated to cost Rs. 697 lakhs and will be very remunerative, as the revenue derived therefrom will, within 5 years after the date of its completion, repay the annual interest on the capital invested. In the 10th year after completion the percentage return is estimated to be 11·9. This scheme is now with the Government of India having been submitted to them for sanction by the Punjab Government during April 1926.

*Haveli Project.* The object of this scheme is to improve the prosperity of certain tracts in the Jhang and Muzaffargarh districts which have become depressed and impoverished by the emigration of tenants and labourers to the more attractive perennially irrigated areas elsewhere in the Punjab. It will comprise a weir at Haveli on the river Chenab below its confluence with the Jhelum, above which canals will offtake on the right and left. That on the left will irrigate the Bar tract of the Shorkot tahsil of the Jhang district and will also pass on supplies to the reservoir formed by the present Sidhnai Dam in the Ravi bed to feed the existing Sidhnai Canal and serve all the areas on the existing Chenab Inundation Canals which offtake below the junction of the Chenab with the Ravi. That on the right is intended to irrigate the *kachhi* land of Jhang in the Uch tract between the Thal highlands and the river. It will also feed the Karam Canal of the Muzaffargarh series. Investigations are being made in order to see whether it is at all practicable to link up the existing Ganesh and Tabri Canals.

This project will command 1·16 million acres of culturable area out of which about 714·266 acres will receive irrigation annually. It is estimated to cost between Rs. 3½ and 4 crores excluding the Ganesh and Tabri Canals.

*The Sutlej Dam Project.* This project really consists of the Bhakhra Dam and certain extensions of the present irrigation systems connected with the Upper Sirhind Canal, the Lower Sirhind and the Western Jumna Canal Extensions.

The Bhakhra Dam is proposed to be built across the Sutlej river in a gorge about 40 miles above Rupar in the Bilaspur State for the storage of surplus water in summer. It will be nearly 400 feet high from foundation level to roadway and will impound 2·58 million feet acres of water at ordinary level and 2·76 million feet acres at emergency level, 10 feet higher.

The average daily draw off is estimated to be 6,075 cusecs, of which, after allowing for losses *en route*, 5,468 cusecs will be available in the canals for 210 days a year.

This scheme when constructed will extend irrigation irrespective of territorial boundaries up to the physical limits of command in the tract between the Sutlej and Jumna rivers which is neither at present irrigated nor comes within the scope of the Sutlej Valley Project now under execution. Between the Ghaggar and Chanting irrigation will be provided for the whole area down to the Rajputana-Malwa Railway between Sirsa and Hissar.

The total gross area commanded by this project is 11·8 million acres out of which irrigation will be given for the first time or intensity increased in 6·87 million acres. The total cost of the project including direct and indirect charges as estimated in 1920 was Rs. 1,445 lakhs. But owing to the general rise in rates and prices

this is now an under-estimate. If the scheme is executed in the next 10 years its cost will probably be in the neighbourhood of 60 per cent. in excess of the original estimate.

The site of the Bhakhra Dam has been twice examined geologically but owing to certain differences in the opinion of experts it is necessary to have the site further examined and this is now being arranged for.

*The Jalalpur Hydro-Electric Pumping Project*, 1925. This will irrigate the tract known as the Pind Dadan Khan-Khushab-Thal tract with water pumped up from the Jhelum river by means of Hydro-Electric power generated at Rasul by dropping a part of the Upper Jhelum Canal supply into the Jhelum river about two miles above the Rasul weir. The tract to be irrigated borders on the right bank of the Jhelum river between Jalalpur and Khushab but only those parts of it will be irrigated where the surface slope is not too steep and which can be irrigated by a lift of not more than 45 feet from the surface level of the Jhelum river. The project will also include within its slope the irrigation of the three inundation canals, *viz*., (1) Pind Dadan Khan Canal, (2) Ahmadabad Canal and (3) Corbynwah Canal.

This project will command a gross area of 167,824 acres out of which 100,695 acres will receive irrigation annually. The total cost (both direct and indirect charges) of this scheme is estimated to be Rs. 61,22,400. Even after taking credit for the interest on realization from sales of crown lands and for enhancement of land revenue, the project fails to be productive with the ordinary schedule of occupiers' rate now in force throughout the Punjab. Even if a nominal average revenue of 12 annas per acre be added, the combined rate approximates only Rs. 5-4 per acre. With an average combined rate for land revenue and water rates of Rs. 7-8 per acre, the project would be productive. The people concerned have stated their willingness to pay even more than this, as they stand to gain abundantly from the benefits which will accrue to them.

## Feasibility of Constructing Dams in the Hills.

When the new Sutlej Valley Canals are completed, most of the Rabi supply in the five tributary rivers of the Indus will have been tapped, but it is estimated that of the total volume of water passing down these rivers during Kharif, 1st April to 30th September, only about one-third will be drawn off by all the canals, perennial and inundation, which will then exist.

For further extensions of irrigation from the five rivers or for an increase in the short supplies in canals already served by them, we are dependent on impoundment of this surplus Kharif water. Of this about one-half is available for storage, the other half being required for scouring the reservoirs.

The total amount of water thus available for storage on the five rivers is about equal to the total volume entering our existing canals (including the new Sutlej Valley Canals) in the Kharif, equivalent to an average daily discharge of 60,000 cusecs for six months or to gross storage capacity of 22 million feet acres.

The following projects have been taken up for investigation so far :—

(*a*) A reservoir at Bhakhra on the river Sutlej for the irrigation of the dry areas in Hissar. This has been described on page 31 *supra*.

(*b*) A reservoir at Thian on the Ravi to impound 273,921 feet acres to give a supplementary supply in the Rabi of 1,000 cusecs, of which 500 cusecs would be passed down the Upper Bari Doab Canal to the Lower Bari Doab Canal and the remainder would be used to relieve short supplies and admit of extensions of irrigation on the former. The height of the dam involved is 200 feet.

(*c*) A project is at present under investigation for a reservoir on the Beas with a capacity of 2 million feet acres to assure the early Kharif supplies of the Sutlej Inundation Canals.

(*d*) *Woolar Lake Barrage.*—A complete project estimate amounting to Rs. 14 lakhs was prepared in 1915 for the purpose of utilizing the Woolar Lake as a storage reservoir. But the negotiations with the Kashmir Durbar became protracted and eventually had to be dropped. The scheme is, therefore, still in abeyance awaiting the possibility of a more favourable attitude on the part of the Kashmir Durbar. It would give an additional water in the Rabi to all the big colony canals which depend for their supplies on the rivers Jhelum and Chenab, the latter river being connected with the former by means of the Upper Jhelum Canal, which acts as a feeder to the Chenab river.

## Waterlogging of the Soil in the Punjab and Measures for its Prevention.

Waterlogging may be defined as the condition that results where the water table is so high that the surface soil is saturated to a degree unfavourable to agriculture and general well-being. The minimum safe depth of the water table cannot be specified : it varies with the constitution of the soil and with the amplitude and duration of seasonal fluctuations.

Waterlogging is not necessarily due to the introduction of canals nor it is a necessary accompaniment of them. It has occurred in tracts before the introduction of canals and still occurs where canals are not among the causes.

The Irrigation Engineers have been conducting experiments ever since the year 1905 in order to determine the best remedy for waterlogging. Various methods have been adopted so far for its prevention and for the treatment of waterlogged areas. Old drains have been improved and new drains have been dug to carry off seepage water from the waterlogged areas which are adjacent to the canals, and, in cases where waterlogging is the result of faulty design of channels causing obstruction to natural drainages, they have been remodelled. In some cases beds of channels have been lined with waterproof materials. To ameliorate the insanitary conditions in and around Amritsar, the subsoil water level has been lowered by means of Hydro-Electric installations and the water thus pumped has been used to replace canal irrigation. But much depends upon the co-operation of the zamindars themselves. Experiments have shown that the cultivators use 20 per cent. more water than would be required to give the same outturn, and some part of this naturally goes into the soil and tends to raise the subsoil water level. If the water were applied with due regard to economy especially in the matter of dividing their fields into compartments of suitable size and delivering the water into each compartment separately by means of a watercourse at one side of it, the irrigated area might be extended by 20 per cent.

In addition to the above, the Punjab Government has appointed a special Enquiry Committee including a Scientific and an Engineer member, the Scientific Research Officer holding the first of these posts. Scientific investigations are being carried out to find out the best means of arresting the progress of waterlogging and of reclaiming the waterlogged areas. The general objects of investigation will be treated under the following heads :—

(*a*) A study of the movements of the water table :—This may involve waterlogging or the inverse problem of dessication brought about by excessive well irrigation.

(*b*) Hydrodynamical problems connected with the design of irrigation works and the problem of slit transport.

(*c*) Field investigations of an agricultural nature.

**Economic Distribution of Supply.**

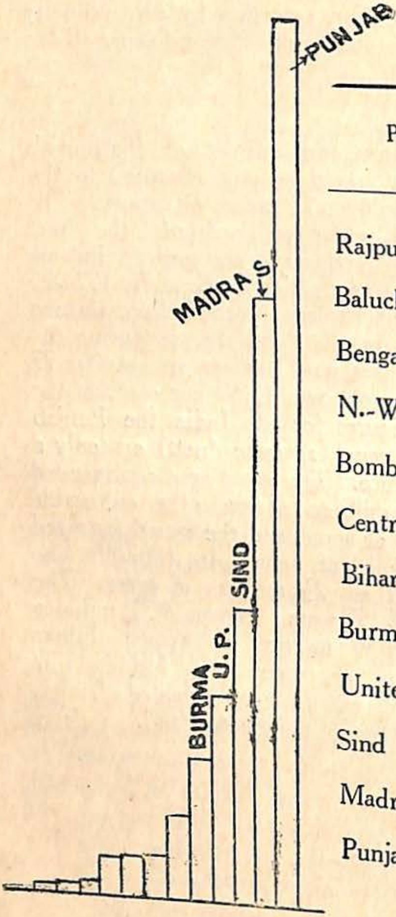
The scientific and equitable distribution of water both at the heads of Distributaries and at the zamindars' outlets has advanced immensely during the last decade owing to the experiments made and designs evolved by various Engineers of the Irrigation Branch, culminating this year (1926) in departmental orders that every reach of every Distributary is to be fitted with a meter

and that every outlet is to be of approved " modular " (*i. e.*, meter) type. This means that not only has considerably economy of supply been effected, thus allowing for extensions of irrigation to areas for which water was previously not available, but that equitable distribution has reduced the opportunities for extortion by corrupt petty officials and has given confidence to the cultivator and especially to the man with a small holding.

**Conclusion.**

The total capital outlay, direct and indirect, on the Punjab Canals (excluding certain works classed as unproductive) to the end of the year 1924-25 has been over 23 crores of rupees. The income is credited to Government under two heads, *viz.*, the direct income mainly derived from water rates and the indirect income derived from land revenue due to irrigation works. In 1924-25 the direct income was a little under 4 crores and the indirect income about 2 crores, making 6 crores in all. The charges during the year were : maintenance 1·63 crores, and interest on capital 77 lakhs ; total 2·40 crores. The profit was 15·69 per cent. to the State. Compared with the figures for all India the Punjab earns two-thirds of the direct canal revenue (nett) on only a quarter of the capital expenditure. The gross area commanded by the Punjab Canals is 21¾ millions of acres ; the culturable area commanded is 18¾ millions of acres, and the actual irrigated area in 1924-25 was 10¾ millions of acres. In 1887-88 the actual irrigated area was less than 2⅓ millions of acres. The principal crops irrigated (1924-25) were : cereals 4·37 millions of acres ; millets and pulses 1·35 millions of acres ; Fibres (cotton and hemp) 1·90 millions of acres, and fodder 1·37 millions of acres. The average outturn on irrigated land is more than 50 per cent. higher than on unirrigated land.

That the Punjab leads all the other provinces in India in irrigation from Government works of all classes is clearly shown by comparing the areas irrigated in all the Provinces during the triennium 1921-24. This is shown in the following statement :—




| Province. | Annual average area irrigated in triennium 1921-24. | Percentage. |
|---|---|---|
| | Acres. | |
| Rajputana .. | 19,422 | ·07 |
| Baluchistan .. | 23,635 | ·09 |
| Bengal .. | 100,492 | ·40 |
| N.-W. Frontier.. | 390,849 | 1·42 |
| Bombay Deccan.. | 428,750 | 1·52 |
| Central Provinces | 431,579 | 1·57 |
| Bihar and Orissa | 960,505 | 3·50 |
| Burma .. | 1,630,794 | 5·94 |
| United Provinces | 2,433,595 | 8·86 |
| Sind .. | 3,436,321 | 12·50 |
| Madras .. | 7,151,988 | 26·03 |
| Punjab .. | 10,465,404 | 38·10 |
| | 27,473,334 | 100·000 |

# CHAPTER V.

## WATER POWER IN THE PUNJAB.

BY LIEUT.-COL. BASIL C. BATTYE, D. S. O., A. M., R. E., A. I. C. E., A. M. I. E. E. M. AM. SOC. C. E., M. AM. I. E. E.,

CHIEF ENGINEER, PUNJAB, P. W. D., HYDRO-ELECTRIC BRANCH.

**History.**

Prior to the war little attention was paid to the water power resources of this Province.

A pioneer development was carried out on the Jhelum in Kashmir State followed shortly by a smaller but in some ways more complicated project for the supply of electricity to Simla. Simultaneously small schemes were constructed in Chamba and Jammu for the supply of the capital towns of these States.

During the war, however, considerable attention had been directed to the importance of conserving fuel resources and of developing water power as a substitute.

In the summer of 1919 the Punjab Government accordingly decided at the suggestion of Mr. F. L. Milne, M. I. E. E., to investigate the power possibilities of a large bend of the river Sutlej near Bhakra. It was originally Government's intention to make simultaneously a hydro-electric survey of the whole Province, but owing to the difficulty of finding suitable staff without interfering with the particular investigation in progress, the survey was not actually commenced until October 1921, after the investigations on the Sutlej had been completed.

This survey was made by Major R. N. Aylward, D. S. O., M. C., A. M. I. C. E., and was continued uninterruptedly for the next 3 years and was eventually completed in July 1924. The resulting report is a very complete one and occupies 8 volumes. For the benefit of the lay reader the whole of this report has been summarised in Part A, which can be obtained from the Government Press, at a comparatively small cost. The report is believed to be the only complete hydro-electric survey so far produced in India and, with certain exceptions, is one of the most complete so far published in any country.

The investigations of the proposed site on the Sutlej river were completed in July 1921. The report was published in considerable detail, so as to facilitate reference in years to come, because it was considered at the time that there was little likelihood

of the project maturing immediately. The report recommended that no work should be started until further expert advice had been obtained regarding certain technical features peculiar to the site. Of these the most important (and that which eventually led to the postponement of the project) was connected with the length of the pipe line, which was so long compared to the head available, that it was anticipated that difficulties would be experienced in the governing of the turbines if the project was to be self-contained and not working in parallel with other installations. A method of getting over this difficulty was suggested, similar to that which had been adopted tentatively on one or two plants in Western America : it was thought advisable, however, to obtain further information with regard to the results obained at these stations before recommending its adoption locally. The proposal in question involved the dissipation directly into heat of large quantities of kinetic energy, which still remains one of the unsolved problems of hydraulics.

As a result of further enquiries Government was advised to postpone the development of the Sutlej site until such time as the project could be made to operate in parallel with existing stations. Acting on this advice the Electricity Board in April 1922, decided to shelve the Sutlej scheme till a later date and to begin its programme of development on some high head site, of which a number were known to exist on the river Beas.

While these matters were under consideration, the site on the Uhl river was discovered in June 1922. This site was just the right kind to replace the Sutlej as a first development, besides being superior to other sites so far discovered. As it was also believed to be capable of meeting all the requirements of the present generation and thereby unifying the supply of the whole eastern half of the Province, the Electricity Board in September 1922, after careful deliberation, recommended Government to drop all local propositions and concentrate on the site in Mandi State.

The site was surveyed during the winter of 1922-23 and a detailed project was worked out during the following summer and completed by December 1923.

The report is contained in five volumes, dealing respectively with the hydraulic, electrical, railway, and the financial and general aspects of the project. Before taking any further action Government decided to have the project thoroughly investigated by a leading firm of Consulting Engineers in London. In order to assist the Consulting Engineers and at the same time to make sure that no local considerations had been overlooked, it was decided to have the scheme examined locally by three committees of experts dealing respectively with the hydraulic, revenue and railway features of the undertaking.

These committees all reported favourably on the project and recommended its adoption at once. Their reports were embodied

in the project and the whole submitted in March 1924 to two leading firms of Consulting Engineers in London, who examined the project on the electrical and hydraulic side, respectively. The first firm then examined the scheme as a whole with special reference to its financial prospects, and in July 1924 recommended Government to proceed with it immediately.

The scheme was next examined in great detail by the Finance Department and eventually by a sub-committee of the Punjab Legislative Council. It was finally passed by the Council without a division in March 1925.

During the following 6 months, negotiations were completed with the Railway Department for the transfer of the railway portion of the project to that Department for construction and arrangements completed for the formation of a separate Branch of the Public Works Department for the construction of the undertaking. The necessary organization was brought into being last winter and works have been in progress since April 1926. If the present programme is adhered to, the first stage should be completed by the spring of 1930.

**The Resources of the Punjab.**

The concentration of all the energies of the available staff on the Uhl River Project naturally diverted attention from the other power resources of the Province, since that Project itself will alone and unaided be able to meet all the demands of the Province as far north as Sialkot, Lyallpur and Gujranwala for the next twenty years. It follows, therefore, that the other water power resources of the Province, at any rate in the south-eastern section, have ceased to be of immediate practical interest.

Any survey of the water power resources of the Punjab must, of necessity, fall into separate sections dealing respectively with the power available in each of the main rivers of the Province. No proper appreciation, however, of these resources is possible without first understanding the physiographical and geological construction of the Punjab Himalayas. The first portion of the general summarising report of the hydro-electric survey, therefore, describes the geography and geology of the Punjab Himalayas, necessarily based upon the work of Messrs. Burrard and Hayden, which has been of great assistance to the engineers engaged on the survey.

The results of the survey may be briefly summarised as follows :—

Geographically the Punjab rivers investigated fall into four classes :—

(1) The Trans-Himalayan rivers, *i.e.*, the Indus and the Sutlej, rising beyond the Great Himalayan range and which have a much flatter slope than the rest.

(2) The Mid-Himalayan rivers, *i.e.*, the Jhelum and the Chenab, rising on the Indian side of the Great Himalayan range, but beyond the Pir Panjal.

(3) The Cis-Himalayan rivers, *i.e.*, the Ravi and the Beas rising between the Dhauladhar and the Pir Panjal, with steeper slopes than either of the former.

(4) The Sub-Himalayan rivers, *i.e.*, the Jumna and several tributaries of these Punjab rivers rising in the Dhauladhar range and crossing no main range of the Himalayas at all.

The slope of the Indus is so flat, that few power sites exist on the main river; although there must be a number of remarkable sites in the inaccessible area beyond the Great Himalayan range, which is of course beyond the area investigated.

There are four sites on the main river, but with available heads varying from 11 to 43 feet. In spite of this, however, owing to the very large discharges available, over 100,000 kilowatts could be developed; but the cost per kilowatt would be high.

As regards the tributaries, an excellent site capable of developing over 50,000 kilowatts exists at the point where the irrigation canal fed by the Swat, a sub-tributary of the Kabul river, emerges from the Malakand Tunnel; the other tributaries are disappointing.

The Sutlej on the other hand, cuts a straight course through all three ranges and although many wonderful sites probably exist beyond the Great Himalayan range and on some of the tributaries beyond the Dhauladhar, the river itself is so flat, that like the Indus it is, with the single exception noted below, relatively devoid of good sites on the main stream. It has also a remarkably narrow catchment area within the limits of investigation and therefore, few tributaries of importance from a power point of view.

The Bhakra bend site, on the main stream, is capable of delivering 88,000 kilowatts on a 363 feet head. If the Bhakra dam is built this site would be capable of delivering 3 times this quantity for 10½ months in a year but would run short of the extra water required during the remaining 6 weeks. As already explained this Project has been fully investigated and reports published in great detail.

The remaining five rivers contain most of the sites of importance reported on. The majority of the best sites on the main streams occur where the rivers cut through the main ranges referred to above.

Of these five the Ravi as a whole is somewhat disappointing, and has no good sites, with the possible exception of one on a tributary—the Ojh.

The Jamna which forms the boundary between the Punjab and the United Provinces is also disappointing in spite of its comparative steepness and no sites of any importance, with the exception of a small one on the Giri have so far been located. On the

upper reaches of the Tons there are probably many good but inaccessible sites.

The Chenab has one valuable site on the main river at Riasi in Kashmir State, capable of yielding 40,000 kilowatts continuously.

Of the three tributaries of the Chenab, the Ans and Malakhani Tawi lend themselves to a valuable combined three-stage development capable of giving over 50,000 kilowatts, while the Jammu Tawi if taken through to the catchment of the Ojh would quite probably yield over 100,000 kilowatts in a three-stage development in the valley of the latter. This project has not, however, been investigated on the ground and is at present merely a proposal.

With the exception of the Beas, the Jhelum is the best of the Punjab rivers. Its value to the Punjab, however, is somewhat abated by the fact that all the sites are located in the territory of Indian States. There are two sites on the main river, one already partially developed by the Kashmir State at Baramula, where the river cuts through the Dhauladhar range, while the other on the Domel loop is capable of delivering more than 100,000 kilowatts in one development. The two large tributaries of the Jhelum—the Kunhar and Poonch also contain valuable sites—that on the Poonch being a multi-stage development capable of yielding well over 100,000 kilowatts.

The Beas is without doubt the most valuable river in the Punjab. With one exception, all the sites are in British territory and the total gross yield is no less than 832,070 kilowatts. The main river itself if developed in the Kulu valley is capable of delivering nearly 250,000 kilowatts. If, however, this were diverted through the Dhauladhar range into the Uhl valley—a project by no means outside the limits of modern engineering—over half a million killowatts could be generated on the site now being developed, which utilises the waters of the Uhl. Of the tributaries of the Beas, the Parbati and the Sainj alone could deliver no less than 165,000 kilowatts in 6 developments, while the Uhl, on the lines now being developed will be capable of yielding eventually no less than 145,200 kilowatts.

It will be seen that the three rivers providing the greatest number of really commercially useful sites are the Beas, the Jhelum and the Chenab. The following is a general summary of the capacity of each river, from which it will be seen that there are no less than 1¾ million kilowatts capable of commercial development in the Punjab at present, provided markets existed for their output. Of these at present only 8,200 kilowatts have been developed and a further 36,000 kilowatts is now under development.

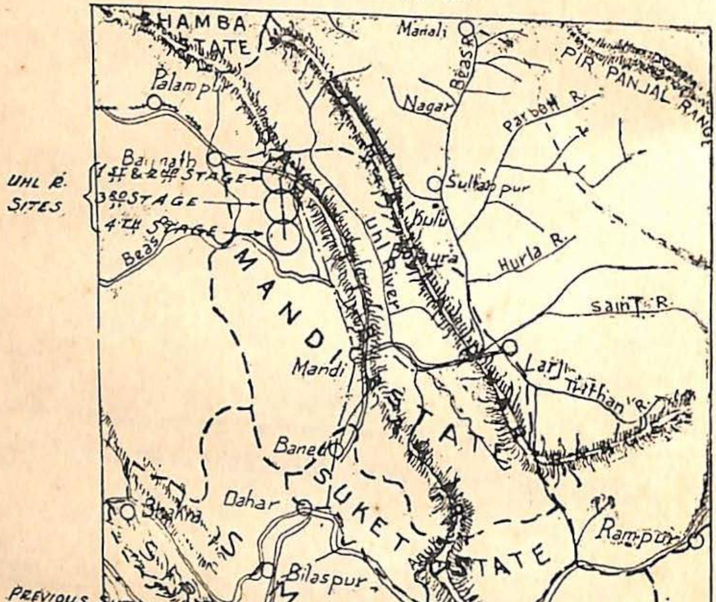
| Item. | Name of river. | Power capable of economical development. |
| --- | --- | --- |
| | | Kilowatts. |
| 1 | Indus .. .. .. | 210,000 |
| 2 | Jhelum .. .. .. | 270,000 |
| 3 | Chenab .. .. .. | 140,000 |
| 4 | Ravi .. .. .. | 190,000 |
| 5 | Beas .. .. .. | 830,000 |
| 6 | Sutlej .. .. .. | 80,000 |
| 7 | Jamna .. .. .. | 50,000 |
| | Total .. | 1,770,000 |

**Developments so far Completed or under Construction:—**

The Kashmir and Simla projects already referred to are essentially medium head developments, using Pelton wheels and high-speed generators of a standard type in which the heads, varying from 390 feet in Kashmir to 540 feet in Simla, developed artificially by the diversion of water from the river into a flume following the contour and ending in a forebay. The Kashmir scheme was constructed by Lt.-Col. Joly de Lotbiniere, R. E., and followed older American practice, using a timber flume and a small forebay; while the Simla project is smaller but more elaborate and more in accordance with European practice, containing in addition to decantation chambers, a large forebay reservoir horizontal pressure duct, surge tank and many of the features embodied in the largest undertakings of this nature.

The Simla project which was designed and constructed by the writer, is chiefly of interest from a scientific point of view on account of its including features which at the time constituted world's records. This Project was constructed primarily in order to supply power for pumping water into Simla. The plant pumps water to a height of 2,760 feet in one lift, which at the time of its installation constituted a world's record for high lift pumping in

Scale................




SKETCH-MAP SHOWING UHL RIVER HYDRO-ELECTRIC SCHEME

one lift. The satisfactory operation of these pumps led to the adoption of this type of plant for an even greater head in the new Guma Water Works recently constructed, where the pumps actually lift water over 4,000 feet in one stage, which again constitutes a world's record.

The Jammu scheme makes use of a local irrigation canal and is chiefly interesting as being one of the first attempts to combine a public supply of power with irrigation.

The Kashmir and Simla schemes are particularly of interest as illustrating the extent to which electric light when based on water power, is taken up by the masses. At the present moment every bazaar shop in Srinagar and Simla uses electric light at a cost varying from 12 annas to a rupee per month.

The Kashmir and Simla schemes were followed immediately by an interesting project in the Amritsar District constructed to the designs of Mr. John Ashford, O.B.E., M.I.E. (Ind.), assisted by Mr. Stephen Legget, M.I.E. (Ind.), primarily as an experiment, to test the possibilities of pumping up sub-soil water by tube-wells.

This is a small scheme and was the first example of hydro-electric development on canal falls in the Punjab. The Amritsar Project was followed by a similar but more up-to-date undertaking at Renala initiated by Sir Ganga Ram, Kt., assisted by Mr. E. S. Crump, I.S.E. and Mr. Stephen Legget. This undertaking is chiefly of interest for the fact that it was the first undertaking of its kind in the Punjab, depending solely on private enterprise. This scheme consists of multi-runner open flume type turbines, similar to those at Amritsar with a similar type of gear drive. The project embodies an interesting and up-to-date syphon overflow, the first of its kind to be used in the Punjab.

The Renala scheme is interesting as being the first application of the power available at low canal falls for pumping up water from canals on to uncommanded areas, a type of development destined to have a considerable future in the Province, as soon as further supplies of irrigation water are available.

At the present moment the only other undertaking in hand is the Uhl river project already referred to.

This has many interesting features none of which, however, are especially novel in hydro-electric development.

This project makes use of the snow-fed waters of the river Uhl, a tributary of the Beas, which joins the latter in Mandi State about 5 miles east of the town of that name.

Water will be diverted through 2½ miles of 9 feet diameter tunnel located in solid granite and at an altitude of 6,000 feet and then dropped through a fall of 1,800 feet to the first power station where 36,000 kilowatts can be generated. From this station

power will be distributed at a pressure of 132,000 volts *via* Pathankot and Dhariwal to Lahore and Amritsar, with branches to Lyallpur, Ferozepur and Ludhiana. This forms the first stage of the project and that now under construction.

The supply of water at present available can be doubled by the construction of a dam 260 feet high. This will create a small lake large enough to store sufficient water to increase the available supply of power to 70,600 kilowatts. In this second stage of development it is proposed to extend the transmission system so as to supply Simla, Ambala and Patiala in the east and also Gujranwala, Sialkot and possibly Montgomery and Fazilka in the west.

A further development contemplated is to take the water through 3 miles of duct and drop it through a second and lower fall of 1,200 feet generating another 48,000 kilowatts, thereby providing a total of 118,600 kilowatts. This forms the third stage of the scheme, in which it is proposed to extend the transmission system so as to supply Saharanpur, Meerut, Delhi and also the districts of Karnal, Panipat and possibly Rohtak as well. The whole system when thus extended will be able to deliver power to over 47 towns extending from Delhi and Rohtak in the south, to Sialkot and Lyallpur in the north, at an average cost of Rs. 95 per kilowatt per year, which is equivalent to 5 pies a unit. There is also a third fall of 750 feet which could be developed later if required, but this has not yet been surveyed.

There already exists a sufficient demand for power to justify the construction of the first stage. There is, however, good reason to believe that five years after the completion of the first stage, the amount of motive power installed in the Province will have nearly doubled. Statistics show that the motive power in the area served by the undertaking has been developing steadily for the last twenty years at the rate of approximately 10 per cent. per annum, *i. e.*, it has been doubling every ten years. This development of motive power in the Province can be directly co-related with the development of irrigation, and as there are still several promising irrigation projects under construction or contemplated, there is no reason to anticipate a cessation in the growth of motive power.

The estimates of power demand and revenue upon which the undertaking has been based do not allow for any increase in the rate of development of motive power due to the demand created either by the project itself or any of the big irrigation projects now in hand. The possible electrification of the railways, the appearance of new industries and the application of electric power to irrigation have not been taken into account. Such developments may, however, be looked for with some confidence and it is quite possible that the demand for power for irrigation and drainage purposes alone will be sufficient in the next twenty years to use all the available power.

## Administrative Problems.

The interesting problems that arise in connection with the natural resources of this Province are, however, by no means limited to the sphere of physical science. The sociological problems falling under the head of administration are no less interesting or important.

This aspect of the question has been dealt with in an addendum to the summarising report (Part A) of the hydro-electric survey.

In this addendum attention has been drawn to the problems involved in developing natural resources on a national scale requiring large blocks of capital at low rates of interest and in consequence good credit, and at the same time of developing these resources with the enterprise and efficiency usually associated with private undertakings and so seldom with Government.

In developing such national resources two types of conditions are usually met with : those countries in which the power resources are many, small and well distributed among the markets, of which England, Switzerland and Sweden are good examples and those in which the sites are few, large and concentrated at a distance from the markets, of which California and the Punjab are good examples.

In the first type a centralised policy is by no means essential, and successful development—at any rate in the early stages—can be secured by separate undertakings under private or municipal control and administration. Even in this type, however, a policy of unification is eventually found essential, as is now being realised even in Great Britain.

In the second type, however, although attempts have often been made to develop on the first system, circumstances have usually necessitated complete nationalisation or complete centralisation in one or two large private corporations.

For such enterprises large blocks of capital at the lowest possible rate of interest are necessary and for this—(except in very exceptional circumstances, which do not at present exist outside Great Britain and America)—Government credit has been found essential.

This means some form of nationalisation : the problem to be solved is how to secure the advantages of such nationalisation without its many disadvantages.

This problem has been discussed exhaustively in the addendum to the summarising report in which the many difficulties associated with the Government management, of what is essentially a business undertaking, have been faithfully portrayed.

Fortunately—at the present moment—we are unhampered by precedent, while on the other hand, there is the experience of other States to go upon in the solution of this interesting problem. The solution proposed involves a compromise.

It is proposed to create a Commission somewhat resembling the Ontario Hydro-Electric Power Commission in Canada and the various Port Trusts in India which operate with much success. This Commission would be entrusted with the control, management and development of all hydro-electric undertakings with a view—not to the earning of revenue for the provincial budget—but to the delivery of power to the consumer at the cheapest possible price. These proposals are at present under investigation. This interesting problem was exhaustively discussed at the International World Power Conference which was held at Wembley in the summer of 1924. Following these discussions, legislation on the lines of these proposals has been worked out and is now under consideration both here and in Great Britain, South Africa and many other countries.

If these proposals eventually mature it is probable that before a generation has passed the Punjab will be supplied with cheap water power distributed in bulk by a chain of stations linked together to form one electrical system, extendiug from Peshawar to Delhi. The effect of this on the development to the Punjab it is impossible to estimate, but there is little doubt that it will probably contribute largely to make this Province one of the most prosperous and progresssive in India.

# CHAPTER VI.

## THE NORTH WESTERN RAILWAY.

By Captain H. W. WAGSTAFF, M. C., R. E.,
Statistical Officer, North Western Railway.

The North Western Railway serves six important provinces of India. First comes the Punjab with its wide irrigated plains dotted with important towns and cantonments, then Sindh in which is situated the Port of Karachi and where extensive irrigation projects are now in hand. On the Frontier, the North West Frontier Province is served by a number of broad and narrow gauge lines, while Baluchistan is traversed by a strategic line through the Bolan Pass with a lengthy extension to the Persian Border. In the recently created Delhi Province the North-Western serves the Imperial Capital, and lastly, the line traverses the western districts of the United Provinces. Junction is made with the East Indian Railway at Saharanpur, Meerut and Ghaziabad and with the Great Indian Peninsula Railway near Delhi. The Bombay Baroda and Central India Railway metre gauge system links up with the North Western at Delhi, Hissar and Bhatinda and the Bikanir and Jodhpur Railways (both metre gauge) connect at Bhatinda and Hyderabad respectively.

Although the volume of traffic on the North Western Railway may not approach that on some of the large British and American lines, there are many remarkable features connected with this great system that may well claim the attention not only of the Railway expert but of the statesman and student of social development. In mileage it can bear comparison with the largest systems in other parts of the world. The many notable bridges such as those over the Indus at Attock, Sukkur and Kotri and over the Sutlej at Ferozepore and Adamwahan ; the lines which penetrate historic mountain barriers such as those through the Khyber Pass and over the Bolan ; the uninhabited desert sections such as those in Sindh and beyond Nushki, all bear witness to the successful solution of engineering problems of the first order : while the range of climatic conditions from the snow-swept Quetta hills to the scorching plains of the Indus add not a little to the complexity of traffic operation.

### Historical.

Although the facilities for inter-communication in the areas now served by the North Western Railway are vastly superior to anything which has existed before, it must always be remembered that a land traversed by large and partially navigable rivers has natural lines of communication which are powerful factors in the growth of

early civilization. A study of the Nile, Tigris and Euphrates might suggest that similar social conditions existed on the banks of the Indus in the dawn of history, yet till three or four years ago no remains of early civilization had been discovered in India which could be placed anterior to the third century B. C. Quite recently, however, important excavations carried out under the direction of Sir John Marshall near Harappa Road Station and at Mohenjodaro near Dokri Station have, at a bound, taken us back another three thousand years, and have established the fact that in the third millennium B. C. the inhabitants of Sindh and the Punjab were living in well built cities, had a high standard of art, and a developed system of writing.

The mists of antiquity at present hide all historical details of that remote past, and it is not until the invasion of the Greeks in 327 B.C. that the Punjab once more comes into view. Though it is impossible to trace with accuracy Alexander's astonishing journey by land and river from the north of the Punjab to the sea, his route could never have been far removed from one or other branch of the present railway, and it is interesting to note that he took ten months to do a journey which the mail now covers in 24 hours. He left little or no mark, however, and it remained for the great empire builders, Chandragupta Maurya, and Asoka, who followed soon after, to make systematic efforts towards supplementing the means of communication provided by nature. Unfortunately the roads, milestones and rest-houses of these and similar enlightened administrators barely lasted beyond their life-time. Later, the Mughals set to work again to open up communications, and paved the way for the coming of the iron horse.

**Early Days of the Railway.**

The beginnings of the line date back to 1855 (two years before the Mutiny) when the Sindh Punjab and Delhi Guaranteed Railway Company was registered; the first section of the line between Kotri and Karachi City (105 miles) being opened some six years later. In 1862 the same Company opened the section between Amritsar and Lahore and by 1870 various other sections were opened giving through connection from Ghaziabad *via* Lahore and Khanewal to Multan Cantonment.

The Punjab Northern State Railway was a State-owned line and owed its inception to the necessity of improving the communications between the Punjab and the North-West Frontier. The first section, Lahore to Jhelum, was opened in 1873 and eventually, Peshawar Cantonment was reached in January of 1883. The first section was originally metre gauge and was converted to broad gauge in 1878, prior to further extension towards Peshawar. The line between Jhelum and Rawalpindi originally contained very heavy grades and was only finally improved to its present ruling gradient of 1/100 as late as 1897.

The line between Kotri and Multan *via* Sukkur, the Nara Canal Bridge and Lodhran was constructed as the Indus Valley State Railway and was opened in 1878. From that year until 1889 all goods and passenger traffic between the Punjab and Karachi had to be ferried across the Indus at Sukkur, the Lansdowne Bridge at that place only being completed in the latter year.

The Eastern section of the Sind-Sagar Railway originally consisted of a number of small lengths in the north of the Punjab of which the Lalamusa-Malakwal and Golra-Basal sections were the longest. The line joining Malakwal to Shershah *via* Bhakkar was not opened until 1890 and that between Kundian and Campbellpur in 1899.

The Southern section of the Sind-Pishin Railway also owes its origin to the necessity for communications on the Frontier. After considerable wastage in life and material, it was eventually decided at the close of the second Afghan War to carry on the construction of this system as fast as possible. The line, which had reached Sibi in 1880, was extended to Quetta *via* the Bolan in 1886 with a length of metre gauge laid along the bed of the nalla in the most difficult section. At the same time the line *via* Harnai was being carried through to Bostan and onward to Chaman through the Khojak in 1892. The Bolan rou e was finally re-aligned and completed with broad gauge throughout in 1891, since which time it has been the main line to Quetta and beyond.

## Reorganization in 1886.

In 1886 the five Railway Administrations which have been mentioned above were amalgamated under the name of the "North-Western Railway" as a Government concern, owned and worked by the State, and the sections then under construction were rapidly completed and opened for traffic. The most important of these were the Bolan route to Quetta and the line joining Malakwal and Shershah *via* Kundian. A map showing the extent of the system at the time of this amalgamation will be found at the end of this article.

After the great famine in 1878 the Famine Commissioners urged the extension of Railways in India for the protection of the country against these disasters, and the importance of irrigation in the same connection was also pointed out. An impetus was thus given to the construction of the Lower Chenab and Lower Jhelum and the Upper Chenab and Upper Jhelum Canal systems, and with the increase in the productiveness of these areas came a corresponding demand for transport facilities. In response to this demand, the Wazirabad-Sangla Hill-Shorkot Road-Khanewal line was opened in sections between 1895 and 1900, and the Malakwal-Shorkot Road and Shorkot Road-Chichoki Mallian branches between 1903 and 1911. With the above developments taking

place in the Punjab it was recognised that the single line from Sukkur to Kotri on the west bank of the Indus would be insufficient to cope with the increasing traffic, and an alternative route on the east of the river was put in hand. A second crossing over the river at Kotri was opened in 1900, since which date the Rohri-Hyderabad-Kotri link has been the main line to Karachi from Northern India.

Later in 1909 the Khanewal-Lodhran Chord was completed and this obviated through trains having to go round by Multan and Shershah. Various other branch lines such as the Ganda Singhwala-Bhatinda section opened in 1899 and the Jakhal-Hissar and Taxila sections completed in 1913, brought the route mileage of the State-owned portion to about 4,000 miles in the last named year.

The construction of these lines was financed by Government and they are wholly the property of the State. There are a number of lines, however, which are either the property of private companies or of Indian States. Some of these were actually constructed by the Company or Durbar concerned while others were constructed by State Agency, the initial capital expenditure being borne in each case by the Company or Durbar. On opening to traffic, the working of each line was taken over by the North-Western Railway, the whole being worked as one system. The first of these companies to come into operation was the Delhi-Ambala-Kalka Railway Company the main line of which was opened in 1891. Then came the Southern Punjab Railway Company, whose agreement with the Government of India was signed in 1895, and whose main line Delhi-Bhatinda-Samasata was opened in 1897. From then onward this enterprising company has made a number of extensions, the last to be opened being that between Jullundur and Ferozepore. The section Bhatinda to Delhi has now become part of the main mail route between Lahore and Bombay.

Besides the above other companies, such as the Amritsar-Patti-Kasur Railway Company, the Sialkot-Narowal Railway Company and the Hoshiarpur-Doab Railway Company have raised capital for the construction of branches, while the Patiala, Kashmir, Malerkotla and Jind Durbars also own sections of line, which are worked by the North-Western Railway. All the above are of broad gauge. The Kalka-Simla Railway, which is 2′ 6″ gauge, and the importance of which lies in the fact that it serves the summer capital of India, was constructed by a private company and opened for traffic in 1903, being purchased by the State in 1906. The Jacobabad-Kashmore and Jacobabad-Larkana narrow gauge Railways are owned by the Sind Light Railway Company.

Turning to the development of the strategic lines during the last 25 years the following sections may be mentioned. The line from Quetta to Nushki was opened in 1905 and was extended to the Persian Border, a further distance of some 300 miles during the

# NORTH WESTERN RAILWAY

**ON JANUARY 1ST 1886**

**WHEN THE FOLLOWING LINES WERE AMALGAMATED:-**

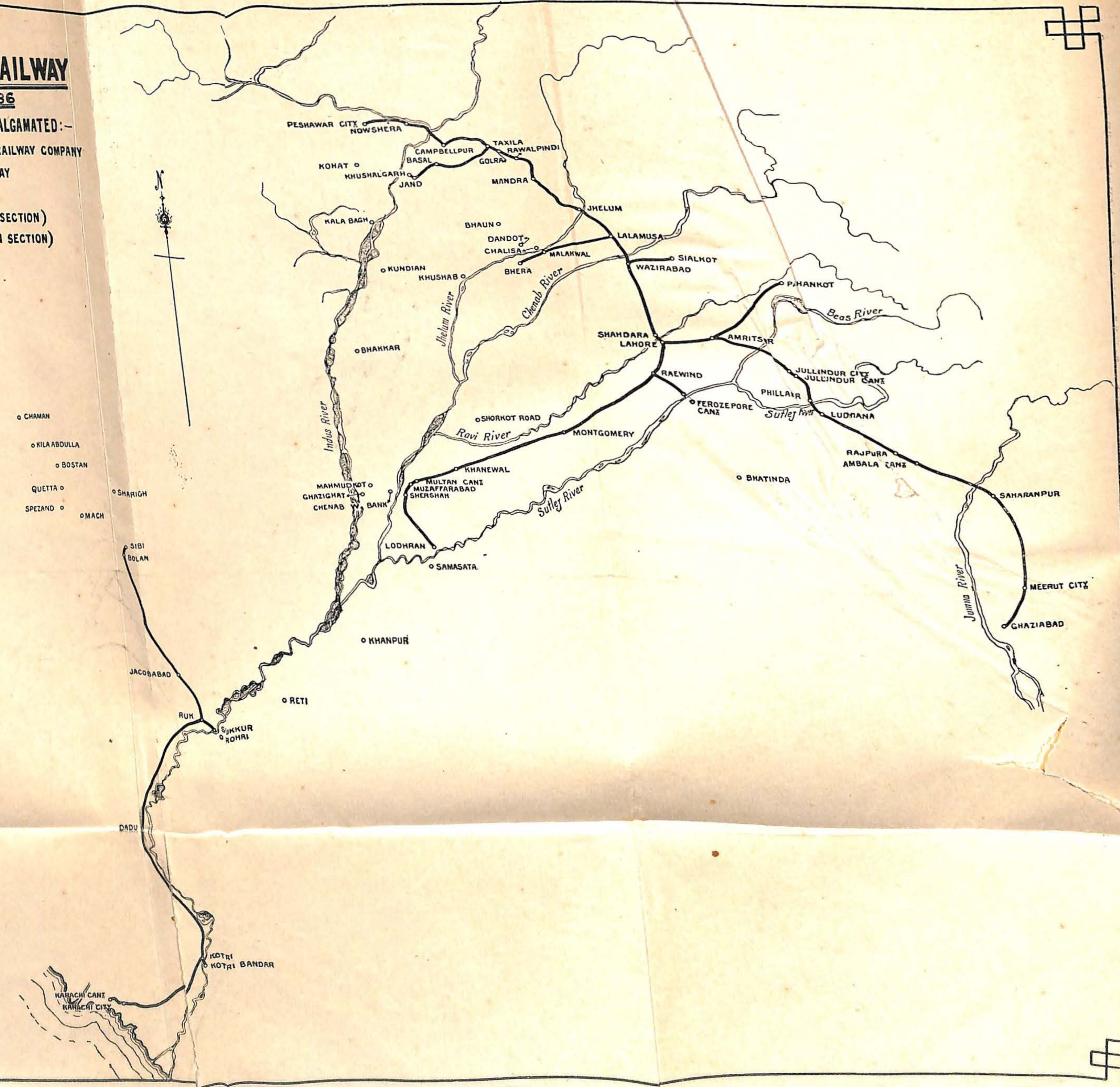
(1) SIND PUNJAB & DELHI GARANTEED RAILWAY COMPANY

(2) PUNJAB NORTHERN STATE RAILWAY

(3) INDUS VALLEY RAILWAY

(4) SIND SAGAR RAILWAY (EASTERN SECTION)

(5) SIND PISHIN RAILWAY (SOUTHERN SECTION)



# NORTH WESTERN RAILWAY

## ON JANUARY 1ST 1886

WHEN THE FOLLOWING LINES WERE AMALGAMATED:–

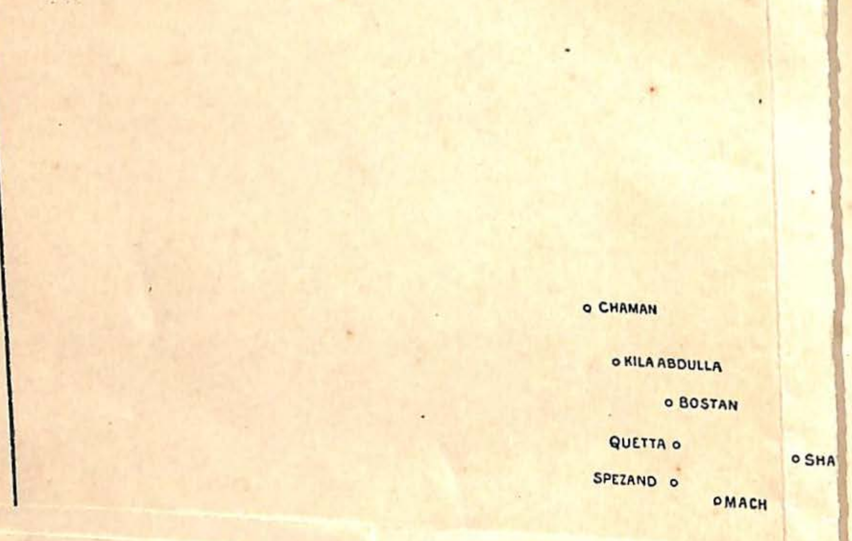
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war. Jamrud was reached from Peshawar in 1901, and the Khyber Railway which traverses the Khyber Pass was opened in the autumn of 1925. The line between Nowshera and Durgai was originally built of narrow gauge, but has lately been converted to broad gauge. In the same way the section Khushalgarh-Kohat-Thall was originally narrow gauge. Khushalgarh to Kohat was converted to broad gauge in 1908, the section onwards remaining 2′ 6″. The lines between Kalabagh on the Indus and Bannu and Manzai have been constructed during the last few years, and a project is now under consideration for a bridge over the Indus at Kalabagh to replace the existing steamer ferry.

**The Position To-Day.**

At the present time, therefore, the main lines of this wide-flung system extend on the one hand from Delhi, the winter capital of the Government of India to the Afghan Frontier beyond the Khyber Pass; and on the other from Simla, the summer capital through the fertile plains of the Punjab to the busy port of Karachi, the third port in importance in India. The present route mileage is slightly over 6,300 miles, while the track mileage including sidings exceeds 9,000 miles. Over 800 miles of the line consists of double track. Of the above route mileage, 4,560 miles are owned by the State, 1,490 miles are owned by various private companies, and 250 miles by Indian States. The greater part of the line (5,800 miles) is of broad gauge (5′ 6″) the remainder being of 2′ 6″ with a small length of 60 c. m. gauge (2′ 0″) on the Frontier. A second map showing the system as it is at present with proposed extensions will be found at the end of this article.

No less than 1,680 miles have been constructed for strategic purposes and these sections are for the most part unremunerative owing to the lightness of the traffic. This, as can readily be realised, has a considerable influence on the working costs of the system as a whole. Another important factor in the same connection is the great distance which separates the line from the sources of fuel supply. Coal, which is used on the greater part of the system, has to be hauled all the way from the Bengal Coal Fields, while oil, which is employed on the Karachi Division, comes from the head of the Persian Gulf. These facts need to be borne in mind when comparing the operating and financial results of the North-Western Railway with those of other lines.

**The Future.**

It might be thought that with the growth of transport facilities described above the requirements of the areas served would have been fully met. This is not the case. The vast irrigation schemes in the Punjab, which have done so much to develop the fertility of the Province are still bringing new tracts under cultivation, and the inception of similar schemes in Sindh will eventually add enormously to the productiveness of that area. Some idea of the influence

of irrigation on transport requirements may be obtained from a study of recent developments on the line between Raiwind and Khanewal. Twelve years ago this area was practically a desert with negligible local traffic. Since that date, however, the goods handed per annum at stations on this section have gone up by 216,000 tons, and this, coupled with the increase in passenger traffic, has necessitated the entire remodelling and enlarging of stations at Kot Radha Kishen, Pattoki, Okara, Montgomery, Mian Channu and Chichawatni.

The widespread demand for feeder lines to give cross connections or to open up new areas is being met by a heavy construction programme, which it is expected will add between 1,600 and 1,700 route miles to the line in the next 5 years, while at the same time comprehensive improvements in track, bridges and station yards are being carried out on the existing lines to meet the requirements of the ever increasing traffic.

**Administration.**

The Headquarters of the Railway are situated at Lahore. At the head of the Administration is the Agent with two Deputies and their Assistants, while the principal officers, Chief Engineer, Chief Operating Superintendent, Chief Mechanical Engineer, Chief Commercial Manager and the Controller of Stores, each has his staff of Deputies and other officers. The line is divided into seven divisions with headquarters at Delhi, Ferozepore, Lahore, Rawalpindi, Multan, Karachi and Quetta, at each of which are stationed Divisional Superintendents with extensive powers and a staff of executive officers for the various branches. There are over 116,000 employees on the pay rolls exclusive of contractors' labour, and with the increase in importance of matters pertaining to staff welfare, a separate branch has been formed for Personnel, which is the chief concern of one of the Deputy Agents and for which there is a special officer on each Division. The Chief Auditor's Office is also situated in Lahore and there is a Statistical Office fully equipped with up-to-date mechanical calculators.

**Workshops and Stores.**

Few people have any idea of the multifarious activities of the various workshops and depots situated in the area east of Lahore known as Moghalpura. In the beginning of the century the accommodation which then existed for the maintenance of locomotives and rolling stock became insufficient for the rapidly increasing demands, and the present Carriage and Wagon Shops were constructed between 1908 and 1910. In 1909 the new Locomotive Shops were started, and completed in 1914, at a total cost of 50 lakhs of rupees. The accommodation left vacant by the removal of these two shops to their new quarters was utilised for the Signal Engineer's Workshop, which, with the development of safety

devices for the control of traffic, had begun to assume considerable importance.

The present Locomotive Shops give occupation to some 5,300 employees, and are capable of thoroughly overhauling 400 engines a year. The Carriage and Wagon Shops employ slightly more (5,800) and have an annual building capacity of 500 four-wheeler units of coaching stock and repair facilities for 5,000 units of coaching stock and 10,000 goods wagons. The Power House which provides the electric power for these shops is situated close at hand, and is equipped with three 2,000 Kilowatt Turbo-alternator sets. This plant also lights the whole of Moghalpura, the station area, staff quarters in the vicinity and the Head Office.

A large area is occupied by the Central Stores Depot with the Office of the Controller of Stores. The value of material in stock at any one time may be upwards of a crore of rupees, while the turnover during the year approaches three crores. The extensive Printing Press which is in the same area gives work to over 400 men, and some indication of its scope may be got from the fact that about a thousand tons of paper are consumed in the year; while the annual requirements of printed matter include items such as 80 million tickets and 40 million telegraph forms. Mention should also be made of the Clothing Factory which supplies uniforms for the staff throughout the line.

The educational facilities provided at Moghalpura are of some interest. A short time ago the Government of the Punjab, recognizing the necessity of providing technical education for Indians, established the Maclagan Engineering College in the vicinity of the Shops so that theoretical and practical training could proceed simultaneously. The College was opened in 1923 and is administered by a governing body of which the Chief Engineer, P. W. D. (R. & B.) is the Head. The course, both theoretical in the College and practical in the Shops, lasts 5 years, during which time students obtain a thorough education in all branches of mechanical engineering. There are generally upwards of 200 apprentices in the Locomotive Shops at any one time, and about 130 in the Carriage and Wagon Shops. Two Apprentices' Homes are provided for those who cannot find accommodation elsewhere, with a hostel for Indian apprentices in the College. Illiterate personnel are taken on in the Shops as shop boys, and after being taught a particular trade, are eligible for the posts of mechanic, and later mistri.

Social amenities are provided in Moghalpura in the shape of an Institute and playing grounds with a hospital in charge of a qualified Medical Officer.

**Some Remarkable Engineering Works.**

No account of the North-Western Railway however short would be complete without some mention of the great engineering works, which its construction has entailed.

The Indus and its tributaries are rivers liable to heavy floods during the summer months, and the construction of the many bridges across these broad streams has taxed to the utmost the resourcefulness, ingenuity and perseverance of the Railway Engineer. The most imposing structure perhaps is the Lansdowne Bridge at Sukkur with its central span of close on 800 feet. The next largest single span (combined with smaller spans) is that at Khushalgarh where the line crosses the Indus at a point where its waters flow through a narrow gorge. The Empress Bridge at Adamwahan crosses the Sutlej by 16 spans of 250 feet and the Kaisar-i-Hind Bridge, an equally imposing structure, crosses the same river at Ferozepore. The Attock Bridge is of interest, not only as an engineering work, but on account of its historic site.

The art of Railway location in a mountainous country is well exemplified by the lines from Sibi to the Afghan Frontier. Here the broad track winding up the steep slopes, often at a gradient of 1 in 25, now leaps the giddy heights of the Chuppar Rift and now burrows beneath the barrier of the Khojak Pass till at length it reaches the Frontier station of Chaman. Further north the line through the Khyber Pass, only recently opened, bids fair to become a classic in railway construction of this nature. In its short 26 miles there are 34 tunnels, 92 bridges, and 4 reversing stations, while the skill with which the steep drop from Landi Kotal to Landi Khana is negotiated is particularly instructive.

Nor do the engineering difficulties always end when a section is open to traffic. The necessity of a sufficient supply of water on the desert sections has led to many curious expedients, and the traveller beyond Nushki may sometimes note as many as 6 auxiliary water tanks behind the engine in its long runs between sources of supply. Moving sand-hills are a feature of parts of Sindh; while even without the formation of these formidable obstacles, sand storms are liable in some parts to cover the track and cause derailments unless gangs are constantly at work to clear the drifts.

**Movement of Agricultural Produce.**

As is to be expected in a great agricultural Province like the Punjab, the chief commodities which contribute to the goods traffic of the line consist of the products of the soil, and it is interesting to note how the development of the various irrigation schemes and improved transport facilities provided by feeder lines has affected the ever growing quantities of agricultural produce moved by the Railway, a great deal of which leaves the Punjab for export to other countries from the Port of Karachi. Wheat stands first in importance, but there are so many factors affecting the movement and export of this grain that the amount carried fluctuates violently from year to year. In 1901, 6·97 lakhs of tons were moved. This rose to 14·77 lakhs in 1904, fell to 5·96 lakhs in 1908, and in 1912

rose to a record of 17·04 lakhs, a figure which was only approached in 1924-25 when 16·91 lakhs of tons were handled.

Turning to gram and pulse, we find that in the first years of the century 1½ lakhs to 2 lakhs tons were handled yearly. These figures, which also fluctuate considerably, rose to a record in 1918-19, when 9·92 lakhs were handled, the figure for 1924-25 being 6·05. "Other grains" have also increased in importance. The figure for 1901 being ·44 lakhs tons as against 6·59 lakhs tons in 1924-25. The movement of oil seeds does not seem to have increased to the same extent as the above mentioned commodities, the quantity moved yearly during the last 25 years varying from 1½ lakhs tons to 5 lakhs. The movement of *jawar* and *bajra* has declined considerably. Between 1901 and 1905 an average of about 1·6 lakhs tons was moved annually, while for the last few years not more than about half a lakh have been carried. When we come to cotton, however, the growth in popularity of this important commodity, and the way in which the Indian product is establishing itself in the world market, may be gauged from the fact that whereas in 1901 ·65 lakhs tons were carried, this rose in 1925-26 to a record figure of 3·02 lakhs tons and contributed no less than a crore of rupees to the revenue earnings of the Railway.

**Passenger Traffic.**

With regard to passenger traffic, there can be no doubt that the inhabitants of the Punjab and adjacent provinces have availed themselves of the facilities for travel which the Railway provides. In 1900 about 20 million passengers were carried on a total route mileage for the entire system of between three and four thousand miles. Last year (1925-26) with a route mileage of a little under double the figure for 1900, no less than 87½ million people travelled on the system; and it would appear that, in view of the projected development of feeder lines, the steady rise in the standard of living and the recent reduction in fares, passenger traffic has not nearly approached the limits of its final development.

# CHAPTER VII.

## PUNJAB FORESTS.

By A. D. BLASCHECK, Esq., F. C. H., Oec. D.,
Acting Chief-Conservator of Forests, Punjab.

The area of forest in the Punjab is small in comparison with that in some provinces, but partly for this very reason it is of considerable economic importance; quite apart from revenue the forests yield for the common good, they meet the requirements of a large agricultural population living under very varied conditions, and the hill forests ensure a regular supply of water to the large and increasing area of irrigated cultivation in the plains. The Forest Department now controls about 6,700 square miles or about 7 per cent. of the total area of the province; further areas of waste and forest are controlled by other civil or military authorities and there are considerable areas of valuable forest in some of the Punjab States. The whole area of forest land is not 10 per cent. of the province, and more than half of this land is waste, not actually bearing forest growth.

Three recognised types are represented; the dry, deciduous and hill forests; their distribution depends largely on rainfall and temperature. In the dry zone of the Southern Punjab the annual rainfall rarely exceeds 15 inches and most of it falls in the monsoon when the temperature averages about 85°F. In these regions the highest temperatures (125°F.) are recorded and, excluding the hills, the lowest (25°F.); such unfavourable conditions account for the limited flora of the zone and poor development of the trees. As conditions become more unfavourable the forest becomes more open, the number of species restricted, and the trees stunted until finally replaced by scrub growth up to the borders of the deserts of Rajputana and Sind. The smallest trees develop the most prodigious roots to reach the low lying ground water, and much land is inimical to the growth of trees owing to concentration of salts in the soil. The following are the more common species of the dry forests: Acacia Senegal, Anogeissus pendula, Calligonum polygonoides (*phog*), Capparis aphylla (*karil*), Prosopis spicigera (*jand*), Salvadora oleoides (*van*), and Tamarix articulata (*farash*).

In the deciduous forest zone the rainfall is 25 inches or more, the mean temperature is rather lower than in the dry forests and the extremes are not so great. The variety of trees and density of the forest is greater; among the more common deciduous trees are: Aegle Marmelos (*bael*) Albizzia spp., Bauhinia spp., Bombax malabaricum (*simal*), Butea frondosa (*dhak*), Cassia fistula (*amaltas*) Cordia Myxa (*lasura*), Dalbergia Sissoo (*shisham*), Eugenia Jam-

bolana (*jaman*), Ficus spp., Holarrhena antidysenterica (*kewar*), Hymenodictyon excelsum, Odina Woodier (*kembal*), Phyllanthus Emblica (*amli*), Spondias mangifera (*ambara*), Stephegyne parvifolia (*kalam*), Terminalia belerica (*bahera*), Terminalia Chebula (*harar*). Shorea robusta (*sal*) one of the most important trees elsewhere in India in this zone occurs only in the Kangra district and eastward ; its development is poor. Valuable forests of male bamboos (Dendrocalamus strictus) are found in the Hoshiarpur and Kangra districts.

In the Himalaya conditions vary greatly, but the rainfall normally exceeds 40 inches and the relative humidity is generally high. At an elevation of 2,000 to 3,000 ft. the deciduous forest merges into typical hill forest and at the approximate altitudes noted the following trees predominate or are of outstanding importance :—

| | |
|---|---|
| 2,000 to 5,000 ft. .. | Pinus longifolia (*chir*). |
| 5,000 to 8,000 ft. .. | Pinus excelsa (*kail*).<br>Cedrus Deodara (*diar*). |
| 8,000 to 10,000 ft. .. | Picea Morinda (*rai*).<br>Abies Webbiana (*tos*). |
| 10,000 to 12,000 ft. .. | Quercus semecarpifolia. |
| 12,000 to 13,000 ft. .. | Betula utilis (*bhuj*), rhododendrons and junipers. |

Pinus longifolia is a gregarious species but in favourable localities it is associated with the following broad leaved trees :—

Bauhinia retusa, Eugelhardtia Colebrookeana (*samma*), Pieris ovalifolia (*ailan*), Quercus glauca (*banni*), Quercus incana (*ban*) Rhododendron arboreum (*bras*). In the deodar zone and at higher elevations a number of trees closely related to European species are found ; among them : Acer, Aesculus indica, Buxus sempervirens, Carpinus, Corylus Colurna, Ilex dipyrena, Juglans regia, Populus ciliata, Quercus dilatata, Quercus incana and Ulmus. These trees grow with the conifers and sometimes to their exclusion. The spruce and silver fir (Picea Morinda and Abies Webbiana) are often gregarious and Quercus semecarpifolia nearly always so. Taxus baccata is often abundant and Pinus Gerardiana is found on the inner ranges where little rain falls.

Soon after the Punjab became a British province difficulty was found in obtaining timber for public works ; exploitation of the hill forests was begun and simple rules for their protection were put into force. A little later the supply of firewood first for the Indus steam flotilla and then railways came under investigation, and with the extension of railways the supply of both firewood and sleepers became problems of increasing importance. The

first Conservator of Forests in the Punjab (Dr. J. L. Stewart) was appointed in 1864 and at about the same time leases of the Chamba and Bashahr State forests were obtained with a view to the supply of deodar railway sleepers. In the plains forests were reserved for the supply of firewood and a number of plantations on alluvial land were started. The insecurity of alluvial land and the advantages of more extensive plantations were soon recognised and extensive planting at Changa Manga was begun in 1866 and within 10 years an irrigated plantation of 10,000 acres had been established. It was calculated that firewood could be grown at a cost of 4 annas per maund while available supplies from plains forests were costing about 5 annas per maund. At these rates it was impossible to import the equivalent 13⅓ seers of coal from the coal fields of Central India and Bengal; but there was some hesitation in allotting irrigable waste for the purpose since in some cases it had acquired a value of Rs. 20 per acre.

In the hills the earliest activities of the Forest Department were surveys of existing supplies of deodar. The Himalayan forests were formed into five divisions corresponding to the five Punjab rivers, and it was soon decided that the forests must be worked with a view to future supplies and not merely to meet the requirements of the time. The numbers of deodar to be felled were fixed arbitrarily or by the aid of some simple calculation of the supplies available, and planting was undertaken where heavy felling had rendered natural reproduction improbable. It is interesting to note that at this time the value of a standing first class deodar tree was Rs. 4 and that owing to the limited supply the use of pine railway sleepers impregnated with chloride of zinc was contemplated and the use of fir and spruce timber for other purposes also received consideration.

The earliest forest administration was carried out under executive rules, some demarcation was undertaken and fellings were controlled, but legislation soon followed the establishment of a regular Forest Department. The provision of the first forest law in India, Act VII of 1865, applied to the Punjab among other provinces. This Act permitted land covered with trees, brushwood or jungle to be brought under its provisions so long as existing rights were not abridged or otherwise affected, but there was no fixed procedure for settling rights or regulating their exercise; provision was made for framing rules for management of the forests. In 1878 the Indian Forest Act, VII, became law and subject to certain amendments still remains in force; there are now 1,299 square miles of Reserved forest and 4,372 square miles of Protected forest constituted in accordance with the provisions of this Act under the control of the Forest Department. The leased forest of Bashahr State and 671 square miles of Unclassed forest make up the total charge of the Forest Department to 6,700 square miles.

Settlements in accordance with the Act have now been carried out in all the more important forests of the province and 3,550 square miles have been surveyed. Working Plans prescribing the treatment, outturn and works of improvement are now in force over 2,437 square miles of forest; they are in course of preparation for a further 204 square miles, and are not at present required for the remaining area. These plans are revised every 10 or 20 years in accordance with the latest silvicultural developments and observation of progress in the forests concerned. It has already been stated that the earliest control of fellings in the hill forests was by numbers of trees arbitrarily fixed; later these numbers were fixed by enumeration of the growing stock and taking account of the time required for second class trees to become mature. Early in the present century it became apparent that while this method checked excessive felling it did not induce adequate reproduction. The openings made often did not admit sufficient light for the development of young trees, many immature trees existed which has lost vitality and could never attain full dimensions and the progress of reproduction was obscured by the scattered nature of the operations. This led in the first instance to the felling of trees in groups; in silvicultural terms a form of Group System replaced the Selection System. In the plains forests and where reproduction by coppice shoots was relied on fellings were usually regulated by area alone.

In the last 25 years forestry in the Punjab has developed still further; while the railways now burn coal the demand for firewood for other purposes has increased. With the extension of irrigation the area of natural forest in the plains is dwindling; 3,000 square miles of forest have already been disforested and of the remaining 2,500 square miles well over a further 1,000 square miles are destined for colonization shortly. Meanwhile the Changa Manga plantation has amply justified its creation and three similar plantations are already in course of formation, two on the Lower Bari Doab Canal (Chichawatni and Khanewal) and one on the Lower Jhelum Canal (Daphar). Shortly three more irrigated plantations are to be started in the Nili Bar on the new Sutlej Valley Canals. These plantations, which will cover some 130 square miles, cannot replace such large areas of natural forest in all respects, but the much more rapid growth of trees under irrigation may replace past supplies of firewood and timber and in times of real scarcity the plantations will supplement the fodder supply. All these plantations will be formed with the aid of experience gained at Changa Manga; shisham (Dalbergia Sissoo) will be the species almost exclusively sown or planted and as at Changa Manga mulberry (Morus alba) is likely to establish itself spontaneously from seed borne by birds and water. Recent experience favours the planting of root and shoot cuttings of shisham rather than sowing; especially where the soil is impregnated with salt or th

supply of water small. It takes shisham 40 to 60 years to attain dimensions fit for timber while 20 years is the normal rotation for shisham and mulberry coppice for firewood. The Changa Manga plantation produces 100 c. ft. of wood per acre per annum and yields a net revenue of Rs. 25 per acre per annum. Mulberry grows faster than shisham and good logs have a very considerable value for a variety of sports gear. It is debatable whether the new plantations are being formed sufficiently rapidly to meet the demand for firewood as supplies from the plains forests diminish; ultimately their area will be inadequate and very inadequate if it is possible to induce the increasing agricultural population to burn firewood and use their cattle dung for manure.

In the hills the deodar is by far the most valuable species and its reproduction and treatment have received the closest attention. Normally it takes a deodar 120 years to attain a girth of about 7 feet and this is the size it is generally sought to grow; larger trees up to 20 feet and more in girth still occur but they are becoming scarce. It has been found that reproduction without undue loss of time can best be ensured by admitting sufficient light for the purpose throughout a compartment of a forest; trees of all dimensions are felled throughout and not here and there in scattered groups. This Uniform System is in accordance with European practice and it has considerable advantages both from the silvicultural and the lumbering point of view especially when large and scattered areas have to be dealt with. The execution and control of felling, logging, sawing and extraction is facilitated by the concentration of operations; again silvicultural skill in raising and tending young crops is focussed on certain compact areas and more effective protection can be afforded where it is most needed. It has also been found that the growth of young deodar is greatly accelerated by burning felling refuse on soil which has not been exposed to the action of the sun; this operation cannot be carried out under proper control if fellings are scattered. The Uniform System is of course not rigidly applicable to all hill forests or even to all deodar forests; uniform crops cannot always be grown on hill sides where factors of locality are seldom constant. Where it is applicable it needs skilled regulation in order to avoid undue sacrifice of vigorous young trees and to prevent large quantities of small timber being put on the market. The annual outturn is fixed by volume after the growing stock has been enumerated and volumes have been assigned to trees according to size. In some cases logs are extracted but the trees are mostly sawn where they are felled into railway sleepers and building timbers and these are then carried by men or wire ropeways to the rivers. Nearly all the sawing and extraction is done in the summer when the hills are quite free of snow; the timber is launched towards the end of the monsoon and reaches the plains depots between December and April. It fetches an average price of Rs. 2 per cubic feet and its extraction costs approximately 12 annas per cubic foot.

The five needled Pinus excelsa (*kail*) occurs with the deodar, often intimately mixed with it is in the same forest, but also in extensive areas of pure forest at about the same altitude. It has a thin bark and is in consequence killed by fire; this circumstance and more or less effective protection from fire in the past 50 years account for a fairly general extension of kail forest throughout the hills. The treatment of this pine and its extraction are similar to that of the deodar; of the hill timbers it is second only to the deodar in quality but until recent years the demand for it was small. Owing to limited demand and its prolific nature the silviculture of the Pinus excelsa has not been the subject of such close study as that of the deodar. In the past it was extensively lopped for litter and manure; this is now prohibited so far as possible, but meanwhile large areas of kail forest have been infected with the fungus Peridermium pini which renders the timber worthless. Kail attains maturity in about 100 years and the price of timber in the plains is about Re. 1-8 per cubic foot.

The three needled Pinus longifolia (chil) yields the only other timber extensively exported from the hills and owing to its gregarious nature the Uniform System is eminently suited to its reproduction. The heavy fall of needles in the hot weather which, if they accumulate, preclude all growth of grass and the comparatively low altitude at which it grows exposes chil more than the other hill species to damage by fire. It is provided with a thick bark which often protects the larger trees from destruction and quite young trees have great power of recuperation, but a crop 10 or 20 years old may be destroyed in a single fire and frequently much older trees are killed. The most effective protection against destruction is now afforded by burning any accumulation of fallen needles before the hot weather when it is intensely inflammable. Chil grows to maturity in about 100 years; its timber is used for a variety of purposes and is now being tried for railway sleepers after impregnation with creosote. Its extraction costs less than timber from the higher hills and delivered in the plains it sells for Re. 1-4-0 per cubic foot. The resin which this pine yields has enabled an important subsidiary forest industry to be developed in the past 25 years. The trees are tapped by means of grooves, 6 inches long, 4 inches wide and ¾ inch deep, cut in the stem and the resin exuded is caught in pots. Throughout the tapping season from March to October the blazes are freshened 5 times a month by the removal of further thin shavings until the grooves extend to about 2 feet in length. As each blaze receives attention the exuded resin is collected and packed for despatch to the distillery at Jallo near Lahore. Twenty to 25 blazes yield a maund of resin in a season and on distillation a maund of resin yields some 30 seers of rosin or colophony and 1¾ gallons of turpentine. The scope for tapping is at present restricted by a fixed rate of

Rs. 4-8-0 for collection, packing and delivery at the distillery which is controlled by the Forest Department and a co-partner who finances the concern. About 50,000 maunds are obtained annually from forests under the Forest Department's control and a further 25,000 maunds from the North-West Frontier Province and States' forests. At the distillery, vacuum plant of the most modern design is employed and the products are of the highest quality; imports of both resin and turpentine are a fraction of the total consumption in India and they are dwindling while exports of Jallo products have already attained considerable proportions. The tapping gives employment to a large number of people in some of the less fertile areas, and the industry yields a profit of about a lakh per annum to the Forest Department.

The oaks and other broad leaved trees of the Himalaya are seldom of any but local value owing to difficulties of extraction, but there are estimated to be 800 square miles of spruce and fir (Picea Morinda and Abies Webbiana) which must some day acquire considerable value for the supply of cellulose if not timber. Both species are being tried as railway sleepers after impregnation with creosote to prolong their life, but without incision the penetration of creosote is inadequate. The timber has to be extracted promptly in order to avoid water-logging or deterioration in transit, and railway freights preclude competition with the cheap timber imported by sea.

There is an established market for bamboos from the forests of Kangra and Hoshiarpur, which yield a revenue of half a lakh or more per annum, and in the latter division efforts have been made to propagate lac with some hope of success.

In Lahore a match factory has been erected by private enterprise, but supplies of the Populus euphratica (*bhan*) wood have proved inadequate, and supplies of kail and fir are not yet entirely satisfactory.

The commercial progress may be summarised by a statement of the average annual revenue and surplus of revenue over expenditure :—

| | | Annual revenue. | Annual surplus. |
|---|---|---|---|
| | | Rs. | Rs. |
| 1869—79 | .. | 6,96,000 | 1,45,000 |
| 1879—89 | .. | 8,25,000 | 2,32,000 |
| 1889—99 | .. | 10,20,000 | 3,22,000 |
| 1899—1909 | .. | 15,51,000 | 4,91,000 |
| 1909—19 | .. | 15,28,000 | 5,69,000 |
| 1919—26 | .. | 40,45,000 | 6,83,000 |

Since 1923 the revenue has averaged Rs. 40,75,000 per annum and the surplus Rs. 13,24,000.

Fodder is the most important product of the Punjab forests after wood, and in times of scarcity the supplies are invaluable. In normal years less than 500 square miles of forest are entirely closed to grazing, and partial closure is enforced in a further 700 square miles. The annual revenue from grass cutting and grazing fees is about two lakhs while the value of rights exercised free of charge is estimated at 20 lakhs. Timber, firewood, and other produce removed by rightholders is estimated to be worth a further 10 lakhs per annum.

Improved silviculture, better protection of the forests, more complete utilization of their produce and cheaper and quicker means of its extraction are normal problems of forest management, but in the Punjab the welfare of a large proportion of its population is more intimately connected with good forest management than is generally recognised. Preservation of the hill forests is not merely the concern of those who enjoy rights in them, or of those concerned with the supply of timber or with the financial returns of forestry; the population of increasingly large canal colonies are dependent on the equable flow of water in the great rivers and this cannot be assured better than by maintenance of forest in the hills wherever permanent and profitable agriculture cannot be established. Tree growth stabilises the soil and retards the drainage of water from the hill sides. Throughout the hills there are now instances of deteriorating forest vegetation and erosion of culturable land as a result of excessive grazing and browsing, and destruction of large areas of fertile land by floods which have covered it with sand has followed denudation of the Siwaliks. The vast sums of money invested in irrigation and the very existence of a large population cannot be risked for the sake of the temporary gain of a comparatively few graziers. In the plains the formation of irrigated plantation to replace the natural sources of wood supply is a matter of more general interest than is commonly realised. Way-side trees provide timber for occasional needs and it is feasible to import some timber from the hills, but there is daily an increasing demand for firewood, occasional trees cannot yield a regular supply nor can firewood be carried long distances at a reasonable cost. It is only suitable situated plantations of considerable area that can avert a firewood famine when the natural forests of the Punjab plains have been colonised; it is estimated the 200 square miles of irrigated plantation are needed to meet the requirements of existing towns alone.

# CHAPTER VIII.

## VETERINARY SCIENCE AND EDUCATION IN THE PUNJAB.

By W. TAYLOR, Esq., I.V.S.,

Officiating Principal, Punjab Veterinary College, Lahore.

The subject of this chapter will be taken up under two heads, first, an account of the Civil Veterinary Department, Punjab, its origin, development, functions, accomplishments, and present strength ; and second, the history of the Punjab Veterinary College, the fountain head of veterinary science in the Province, and the source of supply of trained men for the various grades of veterinary service.

### I.—The Civil Veterinary Department, Punjab.

As early as 1868 Lord Mayo appointed a commission to report on cattle disease in India. Again in 1882 it was urged by Lord Hartington, the Secretary of State, that the newly constituted Department of Agriculture should give attention to the same subject.

In 1883 a Committee at Calcutta recommended the formation of a Civil Veterinary Department, but want of funds prevented its formation.

Three years later the Government of India in a despatch to the Secretary of State said that the formation of a Civil Veterinary Department was necessary "to investigate the practices of the people in regard to the rearing and management of live-stock, and to study and improve the breeds of cattle."

This despatch gave details of the new Civil Veterinary Department to be formed, and said that though its primary duty had been to deal with cattle diseases, its horse-breeding duties would in the future be paramount.

The Government of India, in reviewing the position of the newly formed Civil Veterinary Department classified its duties under the three heads of horse-breeding, animal diseases, and instructions.

Ten years later, as a result of General Taylor's Horse and Mule-breeding Commission of 1900-01, the entire control of horse, mule and donkey breeding in twelve selected districts of the Punjab was transferred to the Army Remount Department, and in these districts the work of the Civil Veterinary Department was confined entirely to cattle. The Commission recommended that the whole

of the responsibility connected with the remounting of the army should rest with one Department.

In 1906 a scheme was formulated for a Dhanni cattle-breeding farm near Sargodha at Rakhs Drema and Risala. The initial cost was to be Rs. 1,20,000, including Rs. 90,000 as the cost of buildings, and an estimated recurring expenditure of Rs. 26,500 to enable 50 bulls to be bred yearly and 800 head of stock to be maintained on the farm. Rs. 90,000 was actually provided by the Punjab Government in the 1907-08 budget, but after many attempts, Mr. Renouf, Director of Agriculture, was unable to secure the transfer of Rakhs Drema and Risala from the Military Department. The matter was quietly dropped in 1910.

In 1910 the Punjab Government proposed that the first step towards the solution of the problems connected with the breeds of cattle in the Hariana and Dhanni tracts was the appointment of a separate Superintendent for the Civil Veterinary Department of the North-West Frontier Province. This appointment received the sanction of the Secretary of State for India but the filling of the post has been held in abeyance up to the present time.

In 1912 the Hissar Cattle Farm of some 39,000 acres was handed over to the Punjab Government by the Government of India.

Since this date the number of Hissar bulls supplied by the Government Cattle Farm, Hissar, to the Punjab districts and the total number of bulls of all breeds purchased each year by local bodies is shown as under—

| | Supplied by Farm. | Purchased by local bodies. |
|---|---|---|
| 1913-14 .. .. | 139 | 154 |
| 1914-15 .. .. | 171 | 219 |
| 1915-16 .. .. | 181 | 201 |
| 1916-17 .. .. | 201 | 216 |
| 1917-18 .. .. | 206 | 213 |
| 1918-19 .. .. | 186 | 205 |
| 1919-20 .. .. | 189 | 256 |
| 1920-21 .. .. | 236 | 261 |
| 1921-22 .. .. | 215 | 257 |
| 1922-23 .. .. | 256 | 339 |
| 1923-24 .. .. | 226 | 318 |
| 1924-25 .. .. | 284 | 431 |
| 1925-26 .. .. | 406 | 616 |

As a result of these operations of the Civil Veterinary Department, there are now 2,253 stud bulls at work throughout the Province, of which about 90 per cent. have come from the Government Cattle Farm, Hissar.

At the present time the Civil Veterinary Department is responsible for cattle breeding to the following extent :—

(*a*) Some 2,000 Hissar and about 200 Dhanni bulls are being maintained as approved stud bulls in the different districts under the supervision of the Civil Veterinary Department. On an average about 350 bulls are being issued yearly from the Government Cattle Farm, Hissar, to meet the present demand in the villages. The net increase after allowing for castings is about 150—200 yearly.

(*b*) The Punjab Government in accordance with the recommendations made by the Civil Veterinary Department under the Dhanni and Hariana cattle-breeding schemes gives annual grants for the improvement of the Dhanni and Hariana breeds of cattle to the following districts equal to the amounts provided for this special purpose by these districts out of District Board Funds :—

To the Attock, Rawalpindi, Jhelum and Mianwali districts for the improvement of the Dhanni breed of cattle a total annual grant of Rs. 22,600.

To the Hissar, Rohtak and Gurgaon districts for the improvement of the Hariana breed, a total annual grant of Rs. 20,000.

This system of giving grants was first introduced in the Dhanni Tract in 1919-20 and then in the Hariana Tract in 1924-25.

(c) There are 6 Government grantee cattle farms of a total area of some 17,600 acres, 3 for the upkeep of the herds of pure bred Montgomery cattle and 3 for Hissar cattle. The total strength of these farm herds is 26 bulls, 1,550 cows and some 1,500 young stock. In addition a Government grantee Dairy Farm comprising an area of 485 acres has been started near the town of Montgomery. The herd required at this farm is 13 bulls and 150 cows. *

The present sanctioned cadre of the Department is as follows :—

| | | |
|---|---|---|
| Superintendents | .. .. | 3 |
| Deputy Superintendents | .. .. | 5 |
| Veterinary Inspectors | .. .. | 28 |
| Veterinary Assistant Surgeons | .. .. | 17 |
| Veterinary Assistants, | 1st Grade .. | 51 |
| | 2nd Grade .. | 104 |
| | 3rd Grade .. | 107 |
| | Total .. | 262 |

*Note.—Agricultural Circulars Nos. 1 and 6 contain detailed instructions on the subject of cattle-breeding, and a full account of the horse mule and donkey-breeding operations in the Punjab.

## II.—The Punjab Veterinary College.

The Punjab Veterinary College owes its origin to that great pioneer in all matters connected with animal industry and veterinary education, the late Colonel J. H. B. Hallen, C.I.E. He was a member of the old Indian Veterinary Department and the first Inspector-General of the Civil Veterinary Department in India.

As General Superintendent of the Horse Breeding Department, he realised that there was no agency for the treatment of the Government stallions, brood mares, and stock which were distributed over the various districts. There was consequently a high mortality from diseases which should either have been prevented or cured. Nor was there any system for providing veterinary assistants for Indian Cavalry and Transport. The necessity for adopting some means for training men in veterinary science was pressing.

The Army Veterinary School at Poona was the first veterinary institution in India. This very useful school was established in 1862 for the training of European and Indian military officers. Another veterinary school to train men for the work of salutris and castrators was organised in 1877. This school remained at the Hapur Remount Depot under the supervision of the Assistant Superintendent of the Horse Breeding Department, the teaching duties being performed by Mr. John Burke. In 1881 the Government decided to close the remount depot at Hapur, in consequence of which decision the hospital practice necessary for clinical teaching became very limited. The Military Department of the Punjab Government had under consideration at the time, proposals to establish a veterinary school in the Punjab. It was finally decided in 1882 by H. H. Sir Robert Eyles Egerton, K.C.S.I., the Lieutenant-Governor of the Punjab, to take over the Hapur Veterinary School and transfer it to Lahore.

A suitable site with an old bungalow on it near the Lahore Medical School was acquired for the purpose. Inspecting Veterinary Surgeon Col. G. Kettlewell was appointed the first Principal. No other veterinary teachers being available, assistance had to be sought from the Medical Department, and two lecturers were obtained to teach Materia Medica and Chemistry.

Thirty-five students came with the Hapur Veterinary School in March 1882. A few *chhappar* stables were put up and some makeshift arrangements were made for a forge in an old out-house, a dissecting room and a shed for operations being arranged in the old building.

Local bodies and Indian States were addressed on the subject of sending in candidates for training. From neighboring provinces candidates were also nominated, the main admission to the college being from the Military Department of India. Additional teachers

were appointed to undertake instruction in Anatomy, and in Equine and Bovine Medicine.

Captain J. A. Nunn succeeded Colonel G. Kettlewell, and during his short tenure of office made considerable additions to the buildings. Lieutenant H. T. Pease was appointed Professor *vice* Mr. Burke in 1888 and was promoted to the principalship in 1896 *vice* Captain Nunn who reverted to military duty. The new principal was an enthusiast with a literary bent of mind. He compiled text-books on Veterinary Medicine, Surgery, Contagious Diseases, Soundness and Ageing of Domestic Animals, and Shoeing of Horses, and wrote many small pamphlets on veterinary subjects which were translated into the vernacular. He started and edited the Punjab Veterinary Journal, which was published in Urdu. The lead was followed by K. B. Dr. Amir Shah, who brought out books on Veterinary Materia Medica and Veterinary Pharmacology. K. B. Sd. Mehtab Shah published works on Veterinary Anatomy, Veterinary Physiology, the Ageing of Domestic Animals, etc. K. B. Sd. Sirdar Shah wrote on Bovine Pathology, Veterinary Obstetrics, Canine diseases, Camel diseases and many other veterinary subjects. Some other members of the staff wrote other text books on the subjects taught by them, and thus the foundation of veterinary literature in the vernacular was laid.

In other provinces a gradual development in veterinary education was going on. The Veterinary Colleges at Bombay, Bengal and Madras were instituted in 1886, 1894 and 1903 respectively. Another for the nominees of the Indian States was inaugurated at Ajmere in 1894. The work of the Civil Veterinary Department was expanding in every province and the amount of training given to the candidates at various institutions was found to be insufficient. As Civilian Veterinary Assistants were expected to be able to combat the outbreaks of serious diseases in the country, the need of raising the standard of training, and of having uniform courses of studies in the various institutions began to be felt.

In 1899 therefore a conference of veterinary officers was held at Ambala. Consequent on their recommendations the course which had hitherto lasted for two years only, was extended to three years and many new subjects were added. No increase in the teaching staff was sanctioned, however, till the abolition of the Ajmere Veterinary School in 1905, when all the students belonging to that institution and three Indian teachers were transferred to Lahore. The Lahore Veterinary School was designated the Punjab Veterinary College after this amalgamation.

New buildings were gradually added as required. In 1903 a ward for cases of contagious diseases and a small Laboratory were built, and an Imperial officer for the teaching of Sanitary Science was appointed. Captain F. S. H. Baldrey was appointed to the

post in 1905 and was succeeded by Mr. S. H. Gaiger in 1906. This enthusiastic officer greatly improved the work of the laboratory but unfortunately contracted glanders, which eventually necessitated his resignation. Major H. T. Pease was appointed Inspector-General of the Civil Veterinary Department in 1907, his position as Principal being taken by Captain A. Smith.

Proposals were invited by the Government for a scheme whereby an increased number of students could be admitted to the college, and more subjects added to the curriculum, in consequence of which additions had to be made to the staff.

Colonel Pease returned to the college in 1912. In 1914 Mr. W. Taylor succeeded Mr. Gaiger. This officer was instrumental in introducing the anti-rabic treatment for animals.

During the administration of Colonel Pease it was decided after considerable discussion to introduce a four years' course of instruction in Urdu for Civilian candidates along with the ordinary three years' course for others, and also to start a short post-graduate course in English. This made necessary several additions to the buildings.

In the meantime the King Edward Memorial scheme necessitated the removal of the Punjab Veterinary College to another site to make room for the expansion of the Medical College and Hospitals. H. H. Sir Louis Dane eventually selected the present site for the Punjab Veterinary College, and Colonel Pease made the best of the opportunity so offered to lay out the present buildings. These new buildings were formally opened by His Excellency Lord Hardinge, the Viceroy, on the 10th of December, 1915.

At the outbreak of the Great War the Punjab Civil Veterinary students volunteered for active service after three years of study. For this reason the four years' Urdu course and the English post-graduate course could not be fully realised at that time.

In 1919 Colonel Pease retired and the services of Colonel G. K. Walker were transferred from Poona, where he had been holding the post of Superintendent, Civil Veterinary Department, Bombay Presidency. He was another enthusiast and had proved himself a very capable officer in the work of organising the Civil Veterinary Department of the Punjab, of which he was the Superintendent from 1901-1912. He came with the realisation that the time had come to raise still further the standard of veterinary education in India. He promulgated another scheme for a four years' course of studies with English as the medium, the number of veterinary books available in the Urdu vernacular being limited. In fact, on certain subjects intended to be added to the curriculum no Urdu books were available at all. The scheme proposed by him was duly sanctioned to take effect from 1st October 1921. Some assistant professors of the college were deputed to England

for special training with a view to teaching Parisitology, Physiology, and Anatomy, while others were trained locally in other subjects.

At the present time the L. V. P. (Licensed Veterinary Practitioner's) diploma is awarded to candidates passing the four years' course. Two Post-Diploma courses each of nine months' duration have been instituted. These are primarily intended for the diplomates of the three years' course.

Besides the addition of certain basic sciences, much more practical and laboratory work has been added to the course and laboratories for practical training in Physiology, Pharmacology, Hygiene, Physics, Chemistry and Biology have been constructed.

The most modern methods of teaching have also been introduced. Dissecting machines, Equine Operating Tables, X-Ray apparatus, etc., have been obtained. The college and hospital are now fully equipped and possess exceptional facilities for teaching purposes.

There was no admission to the vernacular course after 1920, and thus the students passing out of this College in 1924 were the last to receive vernacular training. The first successful candidates of the English Course (L. V. P.'s) passed out in 1925. Since the Punjab Government increased the pay and prospects of the graduates of this course, the demand for admission has considerably increased. The Matriculation examination has been prescribed as the standard for admission to the College. Whether this is a sufficiently high standard to enable the students to take full advantage of the present curriculum is open to doubt and it may be found necessary to raise the standard of education still further in the near future. The teaching of English has also been added to the course of studies to enable the students to follow the lectures more closely.

Since its very foundation the college had been popular and successful. The men who have been trained have done excellent work in this country and abroad. In every theatre of war the alumni of this college performed their duties with credit.

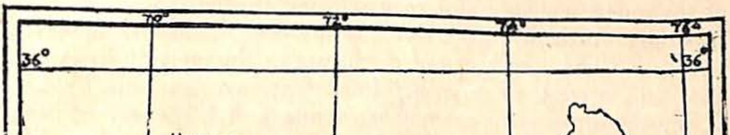
From 1882 to 1901, 601 candidates passed the two years' course of this institution, and from 1900 to 1924, 1,158 candidates passed the three years' course. The four-year L. V. P. course has as yet turned out only ten men, as it is still in its infancy.

# CHAPTER IX.

## THE SALT RANCE

By Professor K. K. Mathur, B. Sc. Hons. (London), A.R.S.M.
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The Salt Range forms a prominent physical feature of north-western India. It rises between the flat plains of the lower Punjab and the elevated Rawalpindi plateau. It is situated in historic




SKETCH OF POSITION OF SALT RANGE ; PUNJAB
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ground, one extremity resting upon the ancient Hydaspes or Jhelum river, the other on the Indus or Aba-Sin (Father of waters). Sir Roderick Murchison aptly described it as the first step in ascending from the lower Punjab to the Himalaya. The mineral deposit which imparts its name to the range has given it a special economic importance which is greatly enhanced by its scientific interest due to the presence of highly fossiliferous strata and the wealth of structural and stratigraphical details in which it abounds.

The range attracted the attention of European investigators long before the annexation of the Punjab by the British Government but the first detailed geological account of the area was published by the Geological Survey of India in 1878. Numerous contributions have since been made for which the reader is referred to the comprehensive Bibliography of Indian Geology issued by the Survey in which the older references will also be found. In fact the Indian geologist hardly requires an introduction to this important area; the present note has been compiled from published accounts for the benefit of the general reader who may wish to have some information on the geology of this area and on problems of scientific interest associated with this hill range. Among the more important of these may be mentioned the origin of the immense deposits of rock salt and the associated gypsum regarding which divergent views have been held by eminent scientists. The occurrence of petroleum in this part of India has also an interest of its own. Important investigations by Dr. G. E. Pilgrim on the mammalian remains in this region have thrown a flood of light on the development of mammalian life during the Tertiary era and the correlation of stratigraphical horizons of this age with those of Europe.

**Physical Features.**

The range stretches over a length of 150 miles east of the Indus but its geographical and geological continuity can be traced on the Trans-Indus side where it takes a sudden turn and borders the Indus for a length of some seventy miles. The situation of the Salt Range is itself peculiar; its connection with the outer Himalayan hills is completely broken by the Jhelum Valley at its eastern end. It forms in fact an elevated border to the Rawalpindi or Potwar plateau with generally a bold escarpment southward, presenting a fine facade of lofty cliffs, bluffs and precipices overlooking numbers of steep valleys and penetrated by profound ravines. Its situation is thus somewhat analogous to the Himalayas which rise above the high plateau of Asia on one side and stand at a much greater difference of level above the low plains of India on the other. An examination of the directions of hill ranges in north-western India shown on the accompanying sketch-map brings out the intimate connection which exists between the orographical features of the Salt Range and the lofty mountain ranges to the north and west. Here the termination of the Himalayas against the meridional mountain ranges of the western frontier finds its reflection in the sinuosities of the Salt Range, and the compressional forces are evidenced by the numerous folds and fractures which characterize the strata of this region.

The upheaval of the Salt Range was generally contemporaneous with that of the Himalayas. The geological structure of the

range has, however, very little in common with that of the Himalayas although strata of the same age with identical fossils in part occur in both. The general structure of the range is uniclinal with a dip to the north and a strong scarp to the south. This is, however, greatly modified by an intricate system of faults and flextures which have produced a complicated structure in some places.

The physical features of the range change considerably in detail from one end to the other. In the east one or two conspicuous hills rise above neighbouring portions of the range; towards the centre the ridges enclose a flat depression called the Son, converge and unite with the superior mass of the Sakesar peak (4,992 feet). Here the direction of the whole range changes abruptly nearly at right angles from west-by-south to a north-westerly course and runs to its western end with a width of two miles and less and an average height of 1,727 feet. This turn and the bend in the Trans-Indus section form a deep, wide and open sinus in the hilly margin of the Indus plains, where that river debouches from the mountains.

The water-parting of the range lies north of the principal crest and except for some tributaries to the Indus the drainage finds its way southward and the elevated range is dissected at numerous places to afford passage to streams from the Potwar. Most of the southern streams from the salt marl are highly saline and brine springs in the salt region are no novelty. The sulphurous springs of the Bakh ravine with the smell of sulphuretted hydrogen emitted by them have attracted considerable attention. Fresh springs are not uncommon upon the plateau or along the borders. Among them may be mentioned those at Choya Sadan Shah, the large sacred spring of Katas, that at the Wycher cliff, Dandot, and those of the Veráláscarp. Sulphurous springs, sometimes warm, occur in other parts of the range. Two such springs near Jaba bring a fair quantity of pertroleum to the surface.

A few saline lakes occur on the northern side of the range. The largest of these Son Sakesar or Samandar occurs to the east of the Sakesar and is about three miles long and one mile wide. The lake of Kalar Kahar has a diameter of about a mile and a depth of only a few feet. Two other lakes are those of Khabaki and Jalúr. The size of these varies with the amount of rainfall.

## GEOLOGY.

A table of the principal geological formations in the Salt Range is given below :—

| | | |
|---|---|---|
| Cainozoic or Tertiary | Upper Tertiary | ..**Siwalik system.**—Soft sandstones, clays and conglomerates with mammalian remains. |
| | Eocene | ..**Nummulitic limestones.**—Containing nummulites, echinoids, lamellibranchs and gastropods. Coal seam with shales at the base in some places. |
| Mesozoic or Secondary | Cretaceous | ..Inconspicuously developed in the Trans-Indus section. |
| | Jurassic | ..Principally developed in the Trans-Indus section of the Salt Range. |
| | Trias | ..**Ceratite beds.**—Flaggy limestones and green marls with Ceratites and other ammonites. |
| Palaeozoic or Primary. | Permo-carboniferous | **Productus limestone.**—Highly fossiliferous, with marl and sandstone in the upper part. |
| | | **Speckled sandstone.**—Red and purple sandstones and shales Lower part fossiliferous. |
| | | **Boulder-bed.**—Glaciated boulders in a fine matrix. |
| | | *Unconformity.* |
| | Cambrian | ..**Salt-pseudomorph series.**—Bright red or green flaggy argillaceous beds with sandy pseudomorphs of salt crystals. |
| | | **Magnesian sandstone.**—Laminated white or cream-coloured dolomitic sandstone. |
| | | **Neobolus beds.**—Grey or dark coloured shales containing Cambrian fossils. |
| | | **Purple sandstone.**—Red or purple sandstone with some shale. |
| | | **Red marl.**—Loose red marl containing gypsum and salt. |

It will be noticed that rocks older than the Palaeozoic are entirely absent, but the oldest fossiliferous strata of the Cambrian age occur in the eastern part of the Salt Range. The only other area in India proper where the lower Palaeozoic rocks occur is a zone of folded strata in the Central Himalayas near the frontier of Tibet in the border tracts of Spiti and Kumaun. The age of the Cambrian beds in the Salt Range is indicated by the presence of the brachiopod Neobolus and a trilobite named Redlichia. These beds are best developed in the eastern part of the Salt Range and the rock salt occurs in the lowermost bed which is a red marl containing gypsum. It has, however, been suggested by Sir Thomas Holland that the salt is of Tertiary age and that its present position is possibly due to the Cambrian beds having been thrust bodily over the salt-marl formation during the process of earth-folding.

The prevalence of marine conditions during the Cambrian period was followed by a long interval for which we have no record of sedimentation in this area, although the interval was wide enough for the deposition of three great systems of strata elsewhere. This imperfection of geological record is equally marked in the whole of Peninsular India. Sedimentation was resumed in the upper carboniferous period under glacial conditions when glaciers appear to have existed over a large part of the Peninsula including Orissa and the Aravallis. In the Salt Range they have left their mark in a peculiar Boulder-bed which contains faceted and striated glacial boulders in a silty matrix. The boulders vary from the size of a pebble to large blocks several cubic feet in volume and consist of granite, rhyolite and other rocks found in the Aravallis in Rajputana. This was probably a home of large snow-fields from which powerful glacier radiated carrying large boulders to long distances.

The Productus limestone formation which overlies the boulder bed and the speckled sandstone group is a highly fosiliferous formation and indicates the presence of an inlet of a sea which was gradually becoming deeper and was in communication with the European area. This formation is well developed in the western part of the Salt Range and is exposed in a series of fine cliffs. Brachiopods, corals, crinoids with gastropods, lamellibranchs and cephalopods constitute the abundant upper Palaeozoic fauna preserved in these rocks. There is a continuous and conformable transition to the Permian and the Triassic beds. The latter are best exposed in the neighbourhood of Chhideru, six miles from Musakhel in the Mianwali District and are known as Ceratite beds from the presence of the Triassic cephalopod Ceratite with other ammonites. Lower and middle Trias are represented after which another cessation of marine conditions is indicated by the absence of beds of the upper Trias and the lower part of the Jurassic period.

The Jurassic rocks are best developed in the Trans-Indus portion of the Salt Range where Cretaceous beds are also represented.

Towards the base of the Tertiary formation in the Salt Range and in some other parts of India there occurs a seam of coal of variable thickness. Besides the Gondwana coal of Bihar, Orissa and the Central Provinces this is the only other important horizon in which workable coal occurs in several parts of India but it is invariably of an inferior quality. These early beds of inconspicuous thickness are followed by a widespread massive formation known as the nummulitic limestone owing to the abundance of the foraminifer nummulites. This horizon can be recognized in Burma, Assam, Garhwal and in the snow-covered peaks in the far parts of Kashmir and Ladakh. The genus spread over Europe and Central Asia and marks an important stratigraphical horizon.

With the close of these widespread marine conditions begins an important era of earth-movements which resulted in the obliteration of the central sea in which the Mesozoic strata were deposited. These were lifted up by a series of earth-movements into lofty mountain chains represented by the Himalayas, the mountain ranges of Central Asia and the Alps. It has already been noticed that the elevation of the Salt Range is essentially a part of the same earth-movement. The rocks of this upper Tertiary period are represented by sands, clays and conglomerates, in which abundant remains of vertebrates have been discovered. The Tertiary period saw the development of mammalian life and a very rich collection of their bones is preserved in these strata. A large number of genera were discovered and described as a result of the early exploration of the Siwalik hills but their exact horizons and the order of succession have been fixed within the last twenty years by the valuable researches of Dr. Pilgrim particularly in the eastern part of the Salt Range.

A remarkable fact in connection with the mammalian fauna is its great abundance during the Pliocene times as compared with the mammalian life of the present day. The life of the Pliocene periods was represented by 15 species of elephants ; the giraffe family consisted of highly specialized and bulky animals which are now practically extinct. The ungulates were represented by pigs, camels, deer, oxen, goats and sheep, many of the Pliocene forms being now extinct. The carnivores and the Primates were well represented. An interesting point about the latter group is the disovery of a form Semnopithicus with close human affinities.

**Petroleum and Coal.**

The occurrence of oil-shows in the Punjab has been known for a long time. Reference has already been made to the oil-

springs of Jaba in the western part of the Salt Range. Petroleum in commercial quantities is won at Khaur in the Rawalpindi district by the Attock Oil Company and the refineries are situated near the town. The total yield from this area during the year 1924 was 11,383,240 gallons, whereas even the unimportant seeps in the Salt Range yielded 919 gallons in 1917. Near Rawalpindi, oil indications occur in beds between the nummulitic limestone and the immense sandstone beds of the Murree series. These consist of gypsiferous marls and clays with Cellular limestone. The Persian oil-region and the Punjab occurrence show a striking geological concordance. At Jaba, in the Salt Range, the oil springs similarly come forth from the uppermost beds of the nummulitic limestone which contains porous limestone, gypsiferous clays and an oolitic limestone forming a prominent ridge. A continuation of this horizon to the north-west and south-east along the border of the range gives indications of oil-bearing beds underground by the presence of tar at the out-crop, although the petrographic character of the Upper Nummulitic undergoes a slight alteration. The Jwalamukhi temple of Kangra does not strictly lie within the scope of this description but it is interesting to note the occurrence of inflammable gases which rise from a hollow in the shrine. Springs of salt water are also known in the locality. Geologically the temple is situated at a distance of a mile from the axis of a regularly curved anticline in the thick sandstones, clays and conglomerates of the Siwalik group. In regard to the future development of oil in the Punjab examinations in the field may lead to important discoveries.

The coal of the Punjab has for many years attracted notice owing to the great importance which a supply of good fuel will possess if found in the vicinity of the Indus. The known deposits are found chiefly in the Salt Range but also occur in the hills north of the Rawalpindi plateau and are of Tertiary (Eocene) age. In most of these occurrences the deposits are commercially unworkable; the more important localities which may be mentioned are Bhaganwala and Dandot in the eastern Salt Range and Isakhel in the Trans-Indus portion, where Jurassic coal also occurs. Mines are worked at Dandot and at Pidh about three miles to the north-east. The coal seam occurs a few feet below the nummulitic limestone and varies in thickness from 18 to 39 inches. The deposit is roughly basin-shaped, the rocks dipping at angles of from 0° to 14°. The coal is a friable lignite and is much jointed. Other localities where coal is worked are Isakhel in the Mianwali district and Tejuwala and Jhakarkot in the Shahpur district. The general run is of an inferior quality containing a large percentage of sulphur as iron pyrites and is very liable to spontaneous combustion. The total production from the Punjab in 1924 was 80,422 tons.

groups furnish excellent building material. The stone chiefly used for building along the range is the smooth fine-grained sandstone of the purple sandstone group. It dresses well and has been used to raise the memorial obelisk on the battlefield of Chillianwalla.

*Ornamental stones.*—The variegated and banded concretionary limestones of the nummulitic rocks above the head of Sardi glen have been quarried a good deal for ornamental purposes. Hematite at the base of the nummulitic has been used in the same way. Gun-flints have been prepared from the chert of the limestone beds. Bipyramidal crystals of quartz occur in the gypsum of Mari salt hill and are worked into necklaces.

# CHAPTER X.

## PUNJAB AGRICULTURE.

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### Area, Soil and Climate.

The British Territory in the Punjab has a total population of nearly 21 millions of people, 60 per cent. of which are directly dependent on agriculture. The total area of British Territory in the Punjab is about 97,000 square miles, *i.e.*, about 62 million acres. Of this 27 million acres are cropped area, 18 million acres are cultivable waste and fallow, and 17 million acres are uncultur-able waste, including the Simla and Kangra hills, river beds, etc., in the province.

The soil in the plains is alluvial. The depth of the deposit is unknown in many areas, and in most places it reaches far below the depth to which any roots penetrate. The character of the soil ranges from almost pure sand, where the water current which deposited it had been swift, to stiff clay, where there had been little or no current. Hard nodules known as *kankar*, and composed largely of carbonate of lime and clay are common in the soils, and more or less hard layers of *kankar* nodules from a few inches to a few feet in thickness are frequently met with. White efflores-cent salts locally known as *kalar*, *reh* or *shora* are to be found in large or small patches in most parts of the plains. Where these salts are at all concentrated they harm or destroy the crops. In most places the soil is fertile medium loam. The permanent water level is at any depth from almost the surface of the soil in such places as along the banks of the Indus in the season when the river is in flood to over 100 feet from the surface in some parts of the plains. On almost all lands the permanent water level is quite low enough to admit of the proper development of the root systems of crops ; although in some parts of the plains lying along some of the main canals there is a tendency to water-logging, presumably due to seepage of water from the canals.

The climate in the plains of the Punjab is hot and dry in summer and mild in winter. From the beginning of May to the end of September it is very hot ; the hottest month is June, the normal maximum shade-temperature (mean of ten years) for that month being between 101° and 110° Fahrenheit for different stations in the province. In many places, however, temperatures of over 120 degrees F. are frequently recorded. Usually there is a drop of

between 20 to 30 degrees F. at night. From June the temperature gradually falls till in January the average maximum shade temperature of the plains is 63° to 71° F. with again a drop of 20° to 30° F. at night. In December and January there are usually a few nights when the thermometer registers very slight frosts, and every few years there are a few nights of frosts which do considerable damage to mango trees and comparatively tender plants. Occasionally also slight frosts occur in November.

**Rainfall and Irrigation.**

The rains chiefly fall between early July and the beginning of September but there are a few showers in January and February. The average annual rainfall ranges from about 7 inches in the plains at Multan to about 34 inches at Rawalpindi which is at the base of the Himalayan Hills and 60 inches or more in some parts of the hills.

The province is fortunate in having many rivers flowing through it. The river Indus flows down its western side while the rivers Jhelum, Chenab, Ravi, Beas and Sutlej travel in a south-westerly direction through its central districts and join the Indus. The Jamna flows down the south-eastern side and finally makes its way into the Ganges. From these rivers during the past 30 years a vast and intricate system of canals has been constructed which has turned the large areas of bare and barren deserts into the most fertile lands in India. The perennial canals of this system irrigate a great part of the central Punjab, while seasonal and inundation canals irrigate considerable areas in the south-east and south-west of the province. There are about 17 million acres of culturable land commanded by existing canals in the province of which 11 million acres are irrigated. Further canal schemes to command 8½ million acres have been sanctioned, and schemes to command another 8½ million acres are under consideration.

In the comparatively small hill areas consisting mainly of the Kangra district, with small parts of the Gurdaspur and Rawalpindi districts, the crops are dependent on local rainfall supplemented by irrigation water led from the mountain streams. The soil in such places is stony and is often terraced with much labour. The principal crops grown are wheat, maize, pulses, and on the irrigated lands rice. In the Kangra district there are also a number of fruit farms. Ordinary farmers in that area supplement their incomes by sheep and goat-breeding. The Kangra Valley Railway which is now under construction will help greatly in opening up and developing that district.

In the sub-montane tract crops are usually dependent either wholly on local rainfall, or on local rainfall supplemented by irrigation from wells. This tract includes the districts of Sialkot, Gurdaspur, Hoshiarpur, Jullundur, Ambala and part of Ludhiana.

Well irrigation is the main-stay in the districts of Sialkot, Gurdaspur, Jullundur and Ludhiana and to a less extent in the Hoshiarpur, Ambala, Karnal and Rohtak districts. The lands are fertile, having been cultivated for ages. The crops are moderately secure, and the population in these areas is the densest in the province, the actual figures being 460 to 500 per square mile, while in the districts of more precarious rainfall in the province the population is only from 100 upwards per square mile. The main crops grown in these districts are wheat, maize, sugarcane, gram and *jowar*.

In the south-eastern districts of the province the rainfall is supplemented partly by irrigation from canals and partly from wells, but a large part of the area is dependent on rainfall only, and is classed among the "insecure" parts of the province, *i.e.*, unprotected from the vagaries of the rainfall by canals or wells. Barley, gram, *bajra* and *jowar* are largely grown there.

In the northern and north-western areas of the province, which include Jhelum, Rawalpindi, Attock, Mianwali and Dera Ghazi Khan districts, and the Khushab tahsil of the Shahpur district the crops are mainly dependent on rainfall. Within this tract there is practically no canal irrigation and well irrigation is difficult and expensive, owing to the great depth of spring level, except in the low lands bordering the rivers.

Between the Indus and the Jhelum river there is a stretch of country known as the "Thal" consisting for the most part of shifting sandhills and patches of jungle, which are fit for little else than grazing grounds for camels. A scheme is under consideration for irrigating this area from the Indus river. The chief crops grown are wheat and *bajra* also gram in Mianwali.

In the south-western parts of the province the rainfall is 5 to 10 inches per annum, but farmers get some help from a number of inundation canals. Agriculture is therefore not very secure except in small areas near the rivers where there is flooding from the rivers or where wells can be worked. There the chief crops grown are wheat and cotton.

## Holdings and Crops.

As regards the size of agricultural holdings in the province and the proportion of cultivated land the following is a brief statement extracted from Publication No. 4 of the Board of Economic Enquiry, Punjab Rural Section, by Mr. H. Calvert, B.Sc., C.I.E., I.C.S.

About 17·9 per cent. of the owners of the cultivated land in the province own less than one acre of land and this is one per cent. of the whole cultivated area.

About 40·4 per cent. own from one acre to less than five acres and this is about 11 per cent. of the whole.

26·2 per cent. own from 5 to less than 15 acres and this is 26·6 per cent. of the whole.

11·8 per cent. own 15 acres to less than 50 acres and this is 35·6 per cent. of the whole.

3·7 per cent. approximately own 50 acres or over and this at a rough estimate is 25·7 per cent. of the whole.

We naturally find the smaller holdings in the most densely populated tracts (*i. e.*, in the old settled sub-montane areas with good rainfalls and the most secure harvests) while the larger holdings are found in the *barani* (rainfall watered) tracts with less rainfall, and in the newly settled canal irrigated areas of the province where the population has not yet reached a stage of high pressure on the soil.

The total areas of the main crops of the province are given below :—

| Serial No. | Crops. | | Sown area (million acres). | | |
|---|---|---|---|---|---|
| | | | Irrigated. | Un-irrigated. | Total. |
| 1 | Wheat | .. | 5·1 | 4·4 | 9·5 |
| 2 | Barley | .. | 0·3 | 0·5 | 0·8 |
| 3 | Rice | .. | 0·7 | 0·2 | 0·9 |
| 4 | Maize | .. | 0·4 | 0·5 | 0·9 |
| 5 | Bajra | .. | 0·3 | 2·3 | 2·6 |
| 6 | Jowar | .. | 0·2 | 0·7 | 0·9 |
| 7 | Gram | .. | 0·9 | 2·8 | 3·7 |
| 8 | Oilseeds | .. | 0·5 | 0·4 | 0·9 |
| 9 | Sugar (raw) | .. | 0·3 | 0·1 | 0·4 |
| 10 | Cotton cleaned | Desi | 1·3 | 0·3 | 1·6 |
| | | American | 1·1 | .. | 1·1 |
| | | Total | 2·4 | 0·3 | 2·7 |
| 11 | Fodder | .. | 2·5 | 1·8 | 4·3 |
| | | Total crops | 13·6 | 14·0 | 27·6 |

## Application of Science to Agriculture.

As regards the application of science to agriculture, the work of the Agricultural Department may be said to have begun with its first experimental farm. This was started in May 1901 at Lyallpur

in the oldest canal colony. The Department was then under the control of the Director of Land Records and Agriculture. The farm consisted of two squares (54 acres approximately) of land, and a man who had taken a diploma in agriculture from the Cawnpore Farm was placed in immediate charge. The farm buildings at that time consisted of a cattle shed, a store room, quarters for the Farm Manager and farm labourers. In 1905, in pursuance of Lord Curzon's scheme for agricultural development, practical steps were taken to organize provincial Agricultural Departments including the Veterinary Department on a more satisfactory basis and a sum of Rs. 20 lakhs was set aside by the Government of India as a recurring grant for this purpose beginning from 1905-06. Of this sum 2½ lakhs recurring were allotted to the Punjab, and this was further supplemented by grants from Provincial revenues. In the same year the first Deputy Director of Agriculture joined the Department and the other staff consisted of one Farm Manager and three Agricultural Assistants. On the 1st July 1906 the Department of Agriculture was separated from the Department of Land Records, and in the same year an Imperial Officer was appointed to be Professor of Agriculture and Principal of the combined Agricultural College and Research Institute which it was proposed should be built; also an Agricultural Chemist joined in 1906 and a start was made with the buildings of the College and Research Institute which were estimated to cost Rs. 4 lakhs. An Economic Botanist joined in 1907. In 1908 posts for four Provincial Service Officers consisting of an Assistant Professor of Agriculture, an Assistant Professor of Chemistry, an Assistant Professor of Botany, an Assistant Professor of Mycology and 6 Laboratory Assistants were sanctioned, but a number of these posts could not be filled up for some years owing to the scarcity of properly trained men.

**Lyallpur Agricultural College.**

In 1909 the Agricultural College and Research Institute at Lyallpur was opened. It was equipped with chemical, botanical, entomological and other laboratories, with a library, herbarium, museum, etc. The students were boarded on the estate as at present. Twenty acres of land were set aside as a students' farm, where students were made to grow plots of different crops and do all connected operations with their own hands. There was an experimental farm of 260 acres on the estate, 100 acres of which were for experimental and demonstration work, and the remaining area was farmed by tenants. On this experimental farm the students studied the farm animals, were given demonstrations with various indigenous and modern agricultural implements, were kept in touch with the agricultural experiments carried out by the Department, and received training in agricultural

operations too extensive to be carried out on their own plots. The botanical section which was started in 1907 occupied 65 acres of land. On 4 acres of this area a teaching collection of plants of biological and economic interest was begun. Eight acres were put under fruit experiments, 30 acres were reserved for botanical work on cottons and wheats, and the remainder for botanical work on other crops. Among other things the students received tuition there in the crossing and selection of plants as well as the testing of varieties of crops and other work connected with the evolution of improved types.

The College began its work with only a three years' Diploma Course in English, which included a training in practical agriculture, with theoretical and practical instruction in such sciences as are of direct assistance to farmers, *i.e.*, Botany, Entomology, Chemistry, Physics, Veterinary Science, Land Revenue Systems of the province, etc. The standard of education for entrance to the course was the University Matriculation Examination or its equivalent, and men who went successfully through the course were eligible for posts of Agricultural Assistants and such like in the Department as well as for employment on private farms. A small workshop was opened in 1910 to facilitate repairs, etc., to apparatus required by the institute, and from the years 1912 to 1915 a few lectures on agricultural engineering were sometimes arranged for. In 1912 a dairy with 20 cows was started to enable the Professor of Agriculture to teach the students practical dairying as a part of the Diploma Course. In the same year a six months' vernacular course of practical farming was opened for young men who wished to take such a course. In 1915, on the appointment of an Agricultural Engineer to the Department, the students began to get a very useful course in agricultural engineering, including land surveying, handling of tools, working in wood and iron, the use of machinery and other agricultural engineering matters with which modern farmers should be acquainted ; also they were put in touch with problems connected with the evolution of improved implements, water lifts, tube wells, etc.

In 1917 the College was affiliated to the Punjab University and the four years' Diploma Course was remodelled to form the present four years' course for the B.Sc. Degree in agriculture. To enable us to meet as far as staff and other facilities would permit the wishes of those who cannot, or do not desire to go through the Degree Course, a two years' leaving certificate course was started. For this the students attend the classes for the first year of the B.Sc. (Agriculture) Degree, and in the second they join a class specially arranged for them by which they devote most of their time to the study of practical agriculture. The arrangement gives boys who are clever enough to gain scholarships a chance to do so, and so get through the whole Degree Course.

In 1918 a Vernacular Course of one year's duration was started for certificated teachers of the Education Department to enable them to teach agriculture in rural Vernacular Middle Schools, and in 1924 a course extending over 1½ months for *Lohars* (village blacksmiths) was started. The instruction given in the latter course includes oil engine driving, running repairs, maintenance of the simpler forms of improved implements, etc. This course was started as it was found that the introduction of modern agricultural implements and machinery including ploughs, reapers, harrows, sugar mills, oil engines, etc., etc., was being greatly hampered on account of a dearth of men who understood them, and who could effect simple repairs.

With the gradual development of the courses of instruction there have been additions and improvements to the laboratories and other parts of the Institute. For example, a new wing has been added to the chemical section and another is being built; a new workshop has been erected and the engineering section has been greatly extended. The botanical area has been extended to 120 acres, and the experimental farm is now 500 acres.

There is accommodation for 200 students in the College, and about 60 students are admitted each year to the main course. Of this number 5 seats are reserved for Indian States and 9 for other provinces. Extensions to the College are greatly needed in many directions, and the more obvious of these are being provided for in a programme of development of the Department which has been drawn up. The total expenses which students have to meet, inclusive of cost of living, College fees, etc., in the degree and leaving certificate courses, are about Rs. 40 to Rs. 50 per month and in the vernacular class about Rs. 10 per month.

The students for the main courses given in the Agricultural College are drawn chiefly from the Agricultural Community all over the province, and when they leave the College they impart information of value to agriculturists with whom they come in contact. The result of this, and the fact, as will be seen later, that farmers have pocketed extra profits in hard cash by using the Agricultural Department's seeds, implements, methods of cultivation, etc., has been the creation among agriculturists of a growing desire to improve their holdings.

**Agriculture in the Schools.**

Agriculture is also taught in schools, chiefly Vernacular Middle Schools, in the province by the Education Department with the advice and help of the Agricultural Department. These schools are provided either with a school farm of 3 to 5 acres area or a school garden of ¼ acre, and there are now about 70 schools teaching this subject. It is considered that the teaching of agri-

culture in schools is of great importance as it reaches masses of people who never attain the Matriculation standard, and awakens in them a thirst for further knowledge and a desire for agricultural improvement. Over 3,000 boys attended these classes last year. These schools are deservedly popular and the Director of Public Instruction is to be congratulated on the work done. He has drawn up a five years' programme of expansion.

**Research and its results: cotton, wheat and sugarcane.**

As regards research the first results of notable value were got from improved varieties of crops selected by the Department. The botanist's time was taken up chiefly by teaching work connected with the College, and attempts to give farmers better crops of wheat and cotton. After a close study of the different types of cottons in the province including their botanical, economic and hereditary characters, a type of acclimitised American cotton known as 4 F was isolated, which became in great demand as soon as it was available to farmers. From a single plant in 1908, its progeny was growing on over 950,000 acres last year in the province. This cotton generally gives a higher yield of *Kapas* per acre and commands a higher price per maund than unselected *Desi* (Indian) cotton. At a moderate estimate it is estimated that last year alone it gave about 3¾ crores of rupees extra profit to farmers in the Punjab. Later, 285 F and 289 F varieties of Americans were evolved, and are growing on thousands of acres of zamindars' lands. 285 F is a heavier yeilder than 4 F and has much better lint. Work on *Desi* cottons was also taken in hand by the botanist soon after he joined the Department, but although a number of higher yielding varieties were discovered and multiplied they were not in great demand owing to the much higher profits which were got by growing Americans. Recently, however, a Hansi selection known as *Bhatla* cotton has been in large demand in the south-east of the province, where there is now a district staff to demonstrate its merits. Altogether there are now over a million acres of improved cottons grown in the province.

As regards wheats, Punjab type 11 which was given out to farmers in 1913 has constantly given 1½ to 2 maunds of grain per acre more than ordinary mixtures, and Punjab type 8-A which was given out in 1919 gives 1½ to 2 maunds of grain per acre more than Punjab 11. The grain of 8-A also gives better results in the flour mill than Punjab 11, and usually commands a premium of some annas per maund in the local market. Also 8-A gives more straw per acre. Other types are in the course of evolution. A total of over a million acres of improved wheats was grown in the province last year, and it was reckoned to give an extra income to Punjab farmers of not less than 84 lakhs of rupees for the year. The area of these wheats is spreading fast.

Ear cockle (Tylenchus scandens) disease in wheats, which has been found to cause damage to the extent of many lakhs of rupees per annum, has been studied, and it has been found that farmers can promptly cure this disease in a single year by the simple expedient of sowing selected clean seed.

As regards sugarcanes, these do not mature seeds in the Punjab, so no new seedlings have been got in this province, but the Coimbatore Experimental Sugarcane Station has come to our aid with new varieties of cane which are doing so well that they may materially alter the position of the sugarcane crop in the economy of Punjab farming. At present there are about 8,000 acres of farmers' land under these improved varieties. Results of practical importance also have been got from studies on the sugarcane disease called Red rot (Colletotrichum falcatun).

A few other crops in the province such as grams, barleys, potatoes, dates, etc., have been tackled as far as staff and other facilities permitted, and improved varieties of these have been sent out to farmers in the recent years ; but more staff has been badly wanted to tackle them more throughly, and crops like jowar, bajra, rice, maize, oilseeds and some of the valuable leguminous crops, fodders, fruits, etc., of the province have not been touched. Government is fully alive to the necessity for specialists on these crops and has already appointed a Fodder Specialist, a Fruit Specialist and a Cerealist while the question of the appointment of a scond Cerealist for work on millets is under consideration. Cotton work which has developed greatly in scope is now in the hands of a Cotton Specialist and is partly financed by the Indian Central Cotton Committee.

## Agricultural Chemistry and Bacteriology.

In the Chemical section a large amount of analytic work on soils, manures, fodders, etc., is done annually, and systematic investigations have been started in order to determine the extent to which soils are being depleted of the various food materials. Combined with this investigation is another in which not only the nutritive values of crops grown in the widely different climatic soil, and other conditions of the province are being determined but an exhaustive effort is being made to arrive at the variations in the important mineral constituents of the crops. The presen Chemist is a specialist in work connected with food values in animal nutrition, and as far as staff and facilities will allow, he is beginning to open up investigations in that direction. The field is wide, very important, and completely unexplored in the Punjab.

Work has been done on the bacteriology of *bara* soils, and useful results have been obtained. The study of the micro-organic

population of the local soils has been started in order to throw light on their seasonal variations and relationships to growing crops. The researches of the present and previous Agricultural Chemists have brought to light remarkable fluctuations in the Punjab in the activities of bacteria concerned in nitrogen fixation, and the object of these researches is to throw light on methods of adding to the stores of nitrogen in the soil and the possibility of bringing nitrogen fixation under control. The work done has been written up for publication as a memoir of the Department of Agriculture in India.

It may be mentioned here that from the surprisingly great intensity of the cropping which can be carried on in the Punjab without the addition of manures to the soil, and with surprisingly little tillage, it is obvious that the soils recover their fertility by natural means much more rapidly than soils do in Britain for example. Important factors in this seem to be that the soil temperatures here are more near the optimum for the work of soil organisms and that the more arid climate allows less washing of nitrates, etc., beyond the reach of the roots of crops. Other factors are concerned, most of which trace back to the greater heat of the sun, but the net result obviously is that farmers here are in a favoured position with regard to competing in the world's markets with their crop products. What is wanted is that science be brought to bear on these natural facilities so that they may be understood and controlled as far as possible to the advantage of the farming community. This, of course, means work, properly qualified staff, and other facilities. The multitude of agricultural problems in this province involving chemical and bacteriological research which, in the interest of farmers, should be attacked as early as possible, have hardly been touched, but Government is alive to the position and a second Agricultural Chemist and Bacteriologist with other necessary staff have just been added to the cadre. It is hoped to add other necessary specialists in the next few years.

**Entomology.**

In the Entomological Section a great deal of valuable work has been done. The life histories of many pests of important crops have been studied, and improvements have been made on the known measures for their control. Sugarcane, maize and jowar stem borers have been studied, and the number of borers found in stubbles after harvest, indicate that the removal of these stubbles after the crop is cut is a practical method of checking the ravages of these pests. It has also been found that the proportion of the plants of the wild Baru grass (Sorghum halepense) affected by these borers was 72 per cent. while in the cultivated crops the proportion was 36 per cent. Therefore "Baru" is apparently responsible for breeding a large number of borers.

A close study has been made of the spotted boll worm (Earius insulana), its parasites, food plants, etc., and a considerable amount of light has been thrown on the subject. Preliminary studies on the pink boll worm (Platyedra gossypilla) indicate that it is a regular pest in the south-east Punjab, but is far more rare in the Montgomery and Lyallpur Colonies and further west. An explanation of this is being sought for. The Indian Central Cotton Committee are greatly interested in this pest, and are financing a five years scheme for further research and investigation on it in the Punjab.

The Kuttra Caterpillar (Amsacta Sp.) which causes extensive damage by eating up the young plants of summer crops has been very successfully dealt with by means of light traps. The question of preserving stored grains from insect attack is also receiving attention, and so far superheating the godowns seems the most promising method of dealing with the pests concerned. Many pests of fruits and other crops have been studied with good results but space forbids their mention.

Rat extermination now forms an important part of the activities of the section and a special staff consisting of two Agricultural Assistants, 4 Mukaddams (Overseers) and 8 fieldmen are unable to meet the demands for their services. The Entomologist calculates that in one year over 9 millions of field rats were destroyed on an area of over 11,000 acres of cultivated land.

**Sericulture.**

Silk work has also received attention and the field of operations is extending rapidly. A filature is to be erected at Shahdara.

**Improved Implements.**

In the engineering section agricultural implements have received considerable attention. Before this section was started Mr. Milligan, the first Deputy Director of Agriculture, working in collaboration with a firm of agricultural implement manufacturers in Scotland, evolved the Raja plough, which has so far stood as a model for further attempts to evolve furrow turning ploughs suitable for the Punjab. But it was not till 1915, when an Agricultural Engineer was appointed that any considerable attention could be paid to the improvement of implements. Since then two main lines have been followed, *viz.* :—

(1) the testing and introduction of modern implements and machinery as they are found in the world's markets and the modification of these to suit local conditions, and

(2) the improvement of indigenous implements.

Even when the Agricultural Engineer was appointed, however, his duties in catering for the wants of the Specialists at the College and Research Institute, Lyallpur, the course of instruction in engineering given to students, and the well-boring work scattered over the whole province, left him little time to devote to agricultural implements and machinery. Nevertheless much valuable work has been done.

Among the more important novelties and improvements put forward are a flexible harrow and a parallel cultivator or horse hoe, comprising the essential features of such implements and eliminating the objectionable features in the modern types. This hoe has been produced in India at little more than half the cost of the imported article.

A bhusa or chaff cutting and pressing machine, an improved bearing for cart wheels, etc., were devised. It may also be mentioned that in the course of his work the Agricultural Engineer has devised a method of building reinforced concrete, which eliminates the use of all forms of wooden shuttering and thereby reduces the cost of construction by 15 to 30 per cent. according to the nature of the work under construction. The system is obviously of very considerable economic importance not only to the Agricultural Department, but to the Railway and Public Works Departments and to others using concrete for constructional purposes. Numerous other lines of work have been undertaken by the Agricultural Engineer as occasion has arisen, but much is still to be done. It is therefore pleasing to note that an Assistant who will work on implements has been added to this section, also a temporary staff of one Assistant Engineer, one draftsman, and one tracer to work up ideas on water lifts and implements.

During all these years, Deputy Directors of Agricultural have been busy at work on improving the simpler country implements. Bar harrows, seed-drills, etc., have been the result, and these are being largely adopted by cultivators. Furrow turning ploughs are coming rapidly into use and chaff cutters are now in very great demand. The latter effect considerable economy in the amount of fodder required for cattle. Local firms have also started to manufacture these machines. The spring tined harrow, which has been adapted for use in this country, is an implement of special importance in *barani* (rainfall) tracts where it can enormously increase the area which a farmer can put under crop in years of scanty rainfall. This is due to the fact that it breaks the surface of about 4 acres of land in a day, whereas a pair of bullocks with a *desi* plough can only break about one acre in the same time. The harrow therefore allows a much larger area of land to be broken while the land is still fit for working after

it has been soaked by rain or irrigation water, and thus extends the area that can be sown. In response to the demand for modern implements the number of both European and Indian agencies dealing with these articles in the province is increasing rapidly.

**Well-boring.**

The well-boring work is also under the Agricultural Engineer, and in this section he has effected very notable improvements. Prior to his engagement in the Agricultural Department he invented a form of strainer tube for tube wells, which could be manufactured in India at less cost than the varieties of strainers on the American market. This strainer was found useful in the work of augmenting the water-supplies in ordinary wells in the Punjab. Before theintroduction of these strainers many bores were unsuccessful because of the collapsing of the walls of the bore. This occurred when the thickness of the impervious stratum above the one from which the water was drawn was insufficient to bridge over the cavity formed by the drawing off of sand in the well water which occurred in such bores. The introduction of strainers which form a porous casing for the bore, enabled farmers to obtain a water-supply from the sub-soil, independently of an impervious stratum, and consequently enormously increased the number of boring successes.

More recently he designed a power boring plant which has proved far more efficient than those available in the market, while costing a great deal less money. This plant is also more handy to move from place to place. He also invented a hand boring plant which costs about Rs. 2,000 as compared with the cost of Rs. 3,000 for the old-fashioned plant. In addition this improved hand boring plant confers a great boon on farmers as it requires only 6 to 8 labourers to work it boring the same depth per day as the old-fashioned plant did with 12 to 15 labourers. The diameters of the bores are also considerably larger, being now 5 to 7 inches, instead of about $2\frac{1}{2}$ inches, as they commonly were with the old machines, consequently the new bores yield considerably more water. Further the new plant bores faster than the old one in unfavourable strata. In the past few years the Agricultural Engineer has devised a strainer which costs less than half the cost of the original form of strainer designed by him, and is equally efficient.

Up to 1924 when the new boring plants were introduced, there were 20 plants at work in the province. Now there are 72 hand boring plants and three improved power boring plants, while a rock boring plant has just been purchased. It is of great importance to the province that the supply of water in the ordinary wells of farmers be increased, and nearly all districts are asking for

help in this direction. In the next few years, therefore, it is proposed to work up to 140 hand boring plants, 10 power boring and 2 rock boring plants, and to divide the province into four well boring circles with a Sub-Divisional Officer in each circle, the whole to be in the executive charge of an officer of the status of an Executive Engineer under the direction of the Agricultural Engineer.

**Water Lifts.**

A considerable amount of work has been done on water lifts by the Agricultural Engineer and several improvements have been achieved. Numerous applications are received every year from landowners in the province who desire advice with regard to various kinds of lift irrigation, and sanction has been received to the temporary entertainment of an Executive Engineer and one Assistant Engineer with the necessary staff to work up the details of lift irrigation projects.

**Conclusion.**

In this paper I have not dealt with the Veterinary College or horse and cattle-breeding operations, which fall under my department, as I understand that they have already been dealt with in another paper, (see Chapter VIII).

I have merely attempted here to give a rough outline of the agricultural conditions of the Punjab and the work done by Government for the development of agriculture; also to show something of the great possibilities of further work in this province. It is impossible in a note like this to go into any details, but I think it will be obvious that the Punjab, with its fertile soil, its large supply of water from its many rivers, the heat of the sun and its virile and progressive peasantry, has assets which, if properly developed, should place the province in a very favourable position in competition with almost any country in the world.

# CHAPTER XI.

## THE LAHORE MEDICAL COLLEGE.

By Lieut.-Col. H. H. Broome, M.B., Ch.B. (Edin.), F.R.C.S. (Eng.), M.R.C.S. & L.R.C.P. (Lond.), I.M.S.

The first Medical College of Lahore was started in the year 1860 in the old artillery hospital in Anarkali, the site of which is now occupied by the Government College. Only 5 students were obtained for the college class and 24 for the "School." The Staff consisted of two Professors.

In 1864 the institution was removed to a site between Railway and Nisbet roads.

In 1870 a new hospital was erected on the site of the present hospital. It had accommodation for 114 patients—Europeans, Indians and Anglo-Indians.

From time to time additions were made, and in 1904 the College was affiliated to the Punjab University.

On the death of King Edward VII in 1910 the Province decided to erect a permanent memorial to his memory. A sum of 17 lakhs was collected by public subscription, to which the Punjab Government added 5½ lakhs and the Government of India 16 lakhs. It was felt that nothing could be more suitable than to devote this money to enlarging and improving the Medical College and its hospitals, as King Edward had always shown a warm personal interest in medical relief. The result is the present institution, which is the best of its kind in India. The King Edward Medical College consists of the college proper and two hospitals—the Albert Victor and the Mayo.

The first two years of the student's medical course is spent entirely in the College, when the subjects of Anatomy, Physiology and Materia Medica are taught. The Anatomical Department contains a large well lighted dissecting room, a well stocked museum, and a modern lecture theatre.

The Physiological Department is entirely new. It has its own lecture theatre, and its laboratories for Chemical and Experimental Physiology and Histology are as fine as any with which I am acquainted in England.

In the third year the students study Pathology, Medical Jurisprudence and Hygiene and begin to work in the hospital. The Pathological Department is new. It has its own lecture theatre and museum, and its laboratories are the most modern in India.

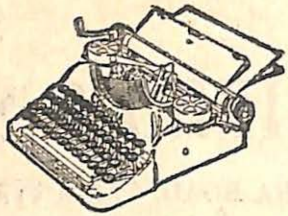
As part of this department there are also two fully equipped and well lighted *post-mortem* rooms.

In the 4th and 5th years the main work of the students is carried on in the Mayo Hospital. This hospital, which is for Indian patients, is a model of what a hospital can be, and the Punjab may well be proud of possessing such a beautifully designed and well equipped institution. Surgeons and Physicians from famous hospitals in Great Britain have visited it and have all expressed surprise that such an up-to-date establishment can be found in India. The main wards of the hospital are devoted to Surgical and Medical work but there is also a Gynæcological and Midwifery ward, and a special department for diseases of the Eye, Ear, Nose and Throat. The wards are large, airy, well lighted, and fitted up in the most modern style. There are three blocks of operating theatres—each block consisting of two theatres with a central sterilising room from which instruments can be passed in to either theatre. One of the two theatres is reserved for aseptic cases, the other for septic ones. The theatres possess ample accommodation for students watching operations and are equipped with every necessity. They would be a credit to any like institution in any country in Europe. The out-patient departments of the hospital are as admirable as the rest of the building. They are three in number, (*a*) surgical, (*b*) medical and (*c*) gynæcological. Each is a separate unit with its own equipment, waiting rooms, examining rooms and theatre for minor operations. They are situated at the front of the hospital on the ground floor, and immediately behind them is a well-stocked dispensary, where the patients receive the medicines prescribed by the Physicians and Surgeons in charge.

There is also in the hospital a clinical laboratory for Pathological and Bacteriological work in connection with the ward, and in addition, the medical wards have side rooms where the students can carry on urine and microscopical examinations of their cases. In connection with the medical work of the hospital there is an isolated block for the treatment of tuberculosis of the lungs, where the patients are placed under open air conditions and the usual sanatorium treatment is carried out.

Clinical theatres are also provided, where the students receive clinical lectures on cases selected from the wards.

In any hospital of the present day the X-ray and electrical department is a most important one both for diagnosis and treatment, and the Mayo Hospital is fortunate in possessing one which is quite up-to-date. Expensive new apparatus for X-ray diagnosis and treatment and various forms of electical, light, and heat treatment have recently been received. This has necessitated an enlargement of the department, and when this is completed the Mayo Hospital will have an X-ray and electrical equipment in keeping with the high standard of the rest of the institution.

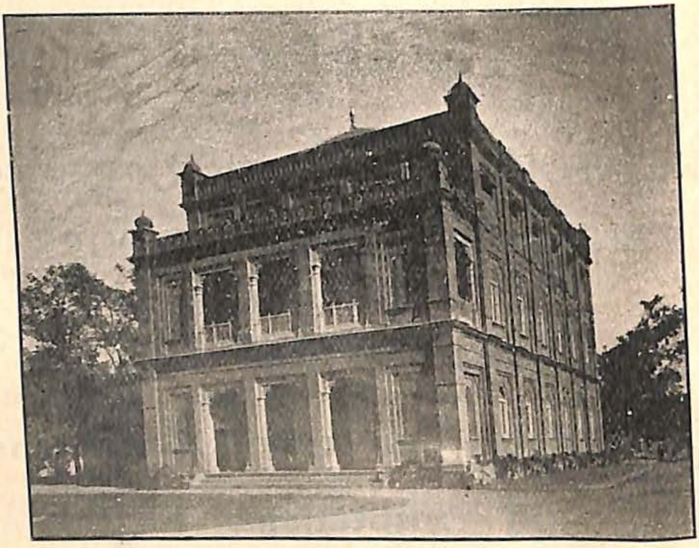


**Some Leading Opinions about our Work:—**

*An extract from a letter No. 525 of 25th March, 1918, from the Government House, Lahore.*

I write to confirm your statement that at the opening of the S. P. S. K. Hall in November 1917, His Honour paid you a tribute for your work as Contractor in erecting the building so speedily and so well.

THE S. P. S. K. HALL.



SIR GANGA RAM TRUST BUILDINGS, THE MALL, LAHORE.



P. W. D. SECRETARIAT :

*Lahore, 23rd November, 1923.*

I am asked to write a certificate for Messrs Barkat Ram and Beli Ram of Baghbanpur. They were the Contractors for the Chemical Laboratory recently completed for the Panjab University in Lahore, which I designed.

It is a large building which cost two and a half lakhs exclusive of fittings. The work throughout is as sound as any I have met within India and I am very satisfied with it. Lala Beli Ram has taken great personal pains over the work which has progressed smoothly from start to finish and of which, I think, they have cause to be proud.

(Sd.) BASIL M. SULLIVAN,

F.R.I.B.E.,

*Consulting Architect to Punjab Government.*